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1960 Annual Report

D. T. Lillie

# CHAPARRAL CONTROL PROJECT

## ANNUAL REPORT - 1960

D. T. Lillie

UNITED STATES DEPARTMENT OF AGRICULTURE

Agricultural Research Service
Crops Research Division
Crops Protection Branch

in cooperation with

Rocky Mountain Forest and Range Experiment Station
Arizona State University
Tempe, Arizona

## SUMMARY OF FINDINGS

1. Repeated annual applications of 2 lb/A 2,4,5-T over a three-year period did not kill an appreciable percentage of treated bushes.

2. Repeated biannual applications of 2 lb/A of 2,4,5-T over a three-year period killed over 90 percent of treated bushes.

3. Pelleted fenuron controlled oak at 8 lb/A kills over 80 percent of treated bushes; at 16 lb/A control exceeds 90 percent. These figures are probably conservative since surviving bushes are at the margins of plots.

4. Lehmann lovegrass reestablished itself 12 - 16 months after treatment with 16 lb/A of fenuron. naturally?

5. Weight of oak sprouts after May and June of 1960 top removal was three times as great in August, 1962 as when tops were removed in September and October of 1960. fall treatment best.

6. Preliminary evaluations indicate that 2-methoxy-3,6-dichlorobenzoic acid may be more effective as a foliar spray than any of the other herbicides tested to date.

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## INTRODUCTION

The following report concerns activities and accomplishments of D. T. Lillie, Research Agronomist for the calendar year of 1960.

The U. S. Forest Service has a group stationed at Tempe, Arizona, to study various aspects of that portion of the Arizona rangeland known as the "Chaparral Type". A major portion of these studies are ultimately aimed at developing management methods to increase water yields from the chaparral watersheds It is possible that manipulations of the plant cover, such as conversion from chaparral to grass, might result in an increase in water yield as well as an increase in the grazing capacity of the rangeland. To this end the Forest Service has enlisted the aid of the Agricultural Research Service to investigate methods of controlling chaparral species.

Our official station is in Tempe, Arizona, on the campus of Arizona State University. We are quartered in a Forest Service office, laboratory and greenhouse space. This affords an opportunity to work in close cooperation with the overall chaparral project.

### The Chaparral Type

The chaparral vegetation in Arizona characteristically grows in thickets on the foothills between the grassland and woodland types. There is no sharp line of demarcation between the types but rather a gradation with the types interspersed.

The chaparral is usually composed of one or two dominant species with lesser amounts of one or more secondary species. Differences in rainfall, soil, slope, elevation, and exposure produce variation in stand composition. Turbinella oak, which is most often the dominant species, frequently comprises about 60 to 90 percent of the plant cover.

The chaparral lies generally in the 3,000 to 6,000 foot elevation range with an annual rainfall of approximately 12 to 25 inches. Precipitation in the chaparral zone in Arizona is divided mainly into two seasons, although rain may occur in every month of the year. The majority of the winter rainfall occurs during the December through March period, while the summer rainfall season occurs in July, August and September. The summer precipitation is usually high-intensity, short duration thunderstorms while the winter rains are frontal rains of lesser intensity and longer duration.

The soils in the chaparral belt are for the most part unclassified. They are poorly developed residual soils derived from granite, slates, and shales.

Research Sites

Field research on chaparral control is being conducted at four sites. The first site is located along the Dewey-Cherry road at an altitude of approximately 5,100 feet. The individual experiments are located at several spots along this road ranging from 95-100 miles from Tempe, Arizona.

This site was selected for its accessibility, uniformity of brush cover and gentle slope. There are also burned over areas available for treatment of sprouting turbinella oak.

A weather station is located approximately 15 miles southeast of Dewey at a somewhat lower elevation. Twenty year records for this station indicate an annual average rainfall of 18.2 inches. April 17 is the average date of last spring frost and October 31 is the average date of first fall frost. The station has a growing season of 197 days.

The second site is located near the Tonto Springs ranger station approximately 120 miles from Tempe at an elevation of about 4,600 feet.

A weather station is located within two miles of the plot area. Twenty year data for the station indicates annual average rainfall of 18.7 inches. The station has an annual average frost free period from May 8 to October 16, with a 161 day growing season.

A third site is located at the Sierra Ancha Experimental Forest approximately 130 miles from Tempe, Arizona. Sierra Ancha is located in central Arizona on the southwest slopes of the Sierra Ancha mountains at an elevation of about 5,100 feet. Average annual precipitation is approximately 25 inches. The growing season is 210 days with an average frost-free period of April 15 to November 11.

A fourth site is located at the Three-Bar wildlife area approximately 90 miles from Tempe at an elevation of approximately 3,200 feet. Climatological data has been kept at the site for only about four years so the annual average rainfall and length of growing season are not known. The annual average precipitation may be estimated at 20 to 22 inches.

INDIVIDUAL EXPERIMENTS

All experiments are under line project CR-f1-27: Develop Methods of Controlling Woody Plants on Arid Pasture and Range Lands.

Experiment Number 1

Title - Evaluation of various herbicides applied as foliage sprays at four seasons of the year.

Background - This experiment was originally designed to explore the possibility that turbinella oak might be more susceptible to foliage sprays of herbicides in one season than in other seasons.

The original intent was to apply a set of treatments in each of four seasons on both unburned oak and on fire sprouts of turbinella oak. However, after two experiments had been applied, those tests placed on unburned oak were destroyed by fire. The test was then discontinued in its original form and those experiments which survived were carried as retreated herbicide evaluation plots.

Objectives - The objective of this experiment is to compare the various herbicides at two rates when applied in September and March for three consecutive years.

Materials and Methods - All spray solutions were delivered from a 25-foot spray boom mounted on an Oliver OC-4 crawler tractor. The applications were made at 30 psi with nozzles and ground speed adjusted to deliver 20 gallons per acre. Two milliliters of Colloidal X-77 wetting agent were added per gallon of spray mixture.

The following herbicides or combinations of herbicides were applied in September of 1958, 1959, and 1960.

| HERBICIDE | LBS/ACRE | DILUENT |
|---|---|---|
| Check | 0 and 0 | ---- |
| 2,4,5-T | 2 and 4 | 1:2 o/w emulsion |
| Silvex | 2 and 4 | 1:2 o/w emulsion |
| 2,4,5-T + Amitrole | 1½ + ½ and 1½ + 1 | 1:2 o/w emulsion |
| Amitrole-T | 4 and 8 | water |
| 2,3,6-TBA + Amitrole | 3 + 1 and 6 + 2 | water |
| 2,3,6-TBA | 4 and 8 | water |
| PBA | 4 and 8 | oil |

These treatments were made to 25 X 40 foot plots arranged in three replications of a split plot field plan. The plot area had been burned in June of 1958 and the oak had sprouted to a height of six to twelve inches at time of treatment.

A second experiment was applied in March of 1959 and retreated in March of 1960. This experiment was contained the same treatments (with the addition of eight and sixteen pounds per acre of dalapon in water) as the earlier experiment. This experiment was also applied to the June, 1958, burn area.

Results and Discussion - The results of these experiments (Tables 1 and 2) serve to illustrate the resistance of turbinella oak to foliar applications of herbicides. Two consecutive years of relatively high rates of herbicides were not sufficient to completely kill even a small percentage of the treated plants.

Even though the significant differences among the treatments were slight (Tables 3 and 4) there was a sufficient spread to enable the poorer and better treatments to be selected.

Amitrole-T and Dalapon were consistently ineffective and no further testing of these herbicides on turbinella oak seems warranted.

The combination of 2,4,5-T and Amitrole had no advantage over 2,4,5-T alone.

The value of combining 2,3,6-TBA and Amitrole was questionable in these experiments. At the time of the last evaluation the combination of 6 lbs. of 2,3,6-TBA with 2 lbs. of Amitrole was equally as good as 8 lbs. of 2,3,6-TBA alone. This would indicate that Amitrole had at least substituted for 2 lbs. of 2,3,6-TBA. This combination treatment was sufficiently interesting that an independent experiment was initiated to evaluate its worth for control of turbinella oak.

Table 1. Percent apparent kill of turbinella oak on two dates of evaluation resulting from application of various herbicides on September 30, 1958 and September 24, 1959.

| Herbicide | lb/A | Percent Apparent Kill evaluated 7-14-60 | evaluated 9-27-60 |
|---|---|---|---|
| Check | 0 | 6 | 2 |
| | 0 | 5 | 2 |
| 2,4,5-T | 2 | 20 | 23 |
| | 4 | 53 | 37 |
| 2,4,5-T + Amitrole | 1½ + ½ | 16 | 17 |
| | 1½ + 1 | 40 | 32 |
| Silvex | 2 | 26 | 25 |
| | 4 | 50 | 37 |
| Amitrole-T | 4 | 13 | 5 |
| | 8 | 23 | 25 |
| 2,3,6-TBA + Amitrole | 3 + 1 | 20 | 25 |
| | 6 + 2 | 26 | 42 |
| 2,3,6-TBA | 4 | 16 | 12 |
| | 8 | 63 | 65 |
| PBA | 4 | 40 | 40 |
| | 8 | 36 | 47 |

Table 2. Percent apparent kill of turbinella oak on two dates of evaluation resulting from application of various herbicides on March 12, 1959 and March 31, 1960.

| Herbicide | lb/A | Percent Apparent Kill evaluated 7-14-60 | evaluated 10-5-60 |
|---|---|---|---|
| Check | 0 | 3 | 4 |
| | 0 | 2 | 5 |
| 2,4,5-T | 2 | 16 | 8 |
| | 4 | 43 | 36 |
| 2,4,5-T + Amitrole | 1½ + ½ | 43 | 20 |
| | 1½ + 1 | 16 | 15 |
| Silvex | 2 | 23 | 10 |
| | 4 | 30 | 15 |
| Amitrole-T | 4 | 11 | 8 |
| | 8 | 17 | 15 |
| 2,3,6-TBA + Amitrole | 3 + 1 | 33 | 35 |
| | 6 + 2 | 46 | 43 |
| 2,3,6-TBA | 4 | 23 | 20 |
| | 8 | 66 | 58 |
| PBA | 4 | 12 | 20 |
| | 8 | 16 | 22 |
| Dalapon | 8 | 4 | 5 |
| | 16 | 4 | 9 |

Table 3. Duncan multiple range test on treatment means of percent apparent kill of burn sprouts of turbinella oak at various times after treatment of the plots in September of 1958 and 1959.

| Evaulation Date | Treatment Means* | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 7-60 | Check | Amitrole-T | 2,3,6-TBA + Amitrole | 2,4,5-T + Amitrole | 2,4,5-T | Silvex | 2,3,6-TBA | PBA |
| | 5 | 18 | 23 | 28 | 36 | 38 | 39 | 39 |
| 9-60 | Check | Amitrole-T | 2,4,5-T + Amitrole | 2,4,5-T | silvex | 2,3,6-TBA + Amitrole | 2,3,6-TBA | PBA |
| | 2 | 15 | 24 | 30 | 31 | 33 | 38 | 43 |

* All means not underlined by the same line differ at the 5 percent probability level.

Table 4. Duncan multiple range tests on treatment means of percent apparent kill of burn sprouts of turbinella oak at various times after treatment of the plots in March of 1959 and 1960.

| Evaluation Date | Treatment Means* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 7-60 | Check | Dalapon | Amitrole-T | PBA | Silvex | 2,4,5-T + Amitrole | 2,4,5-T | 2,3,6-TBA + Amitrole | 2,3,6-TBA |
| | 2 | 4 | 14 | 14 | 26 | 29 | 29 | 39 | 44 |
| 10-60 | Check | Dalapon | Amitrole-T | Silvex | 2,4,5-T + Amitrole | 2,4,5-T | PBA | 2,3,6-TBA | 2,3,6-TBA + Amitrole |
| | 4 | 7 | 11 | 12 | 17 | 22 | 22 | 39 | 39 |

* All means not underlined by the same line differ at the 5 percent probability level.

The most successful applications in these studies were the high rates of 2,3,6-TBA. The plants treated with these rates were severely stunted or apparently dead (Figures 1 and 2). The ratings on these tests were taken on the basis of live stems to dead stems without regard to suppression of growth or reduction of canopy. If the latter two variables were considered the ratings of 2,3,6-TBA plots would have been considerably more impressive. Also the treatment means, on which the Duncan multiple range test was based, include the figures for the 4 lb. application rate which was considerably less effective. An appreciable amount of complete kill could result if the third application of 2,3,6-TBA is as effective as were the previous two applications.

The treatment area contained an excellent stand of Lehman's lovegrass (Eragrostis lehmanniana) which was severely damaged by the 8 lb/acre 2,3,6-TBA applications (Figures 1 and 2).

The phenoxy derivatives, 2,4,5-T and silvex, were only moderately effective in these experiments. The treatments with these herbicides resulted in rapid leaf kill along with a slower, but significant amount of stem kill. However, the plants reacted to these herbicides much as if they were contact herbicides. The plants recovered and resprouted with apparently

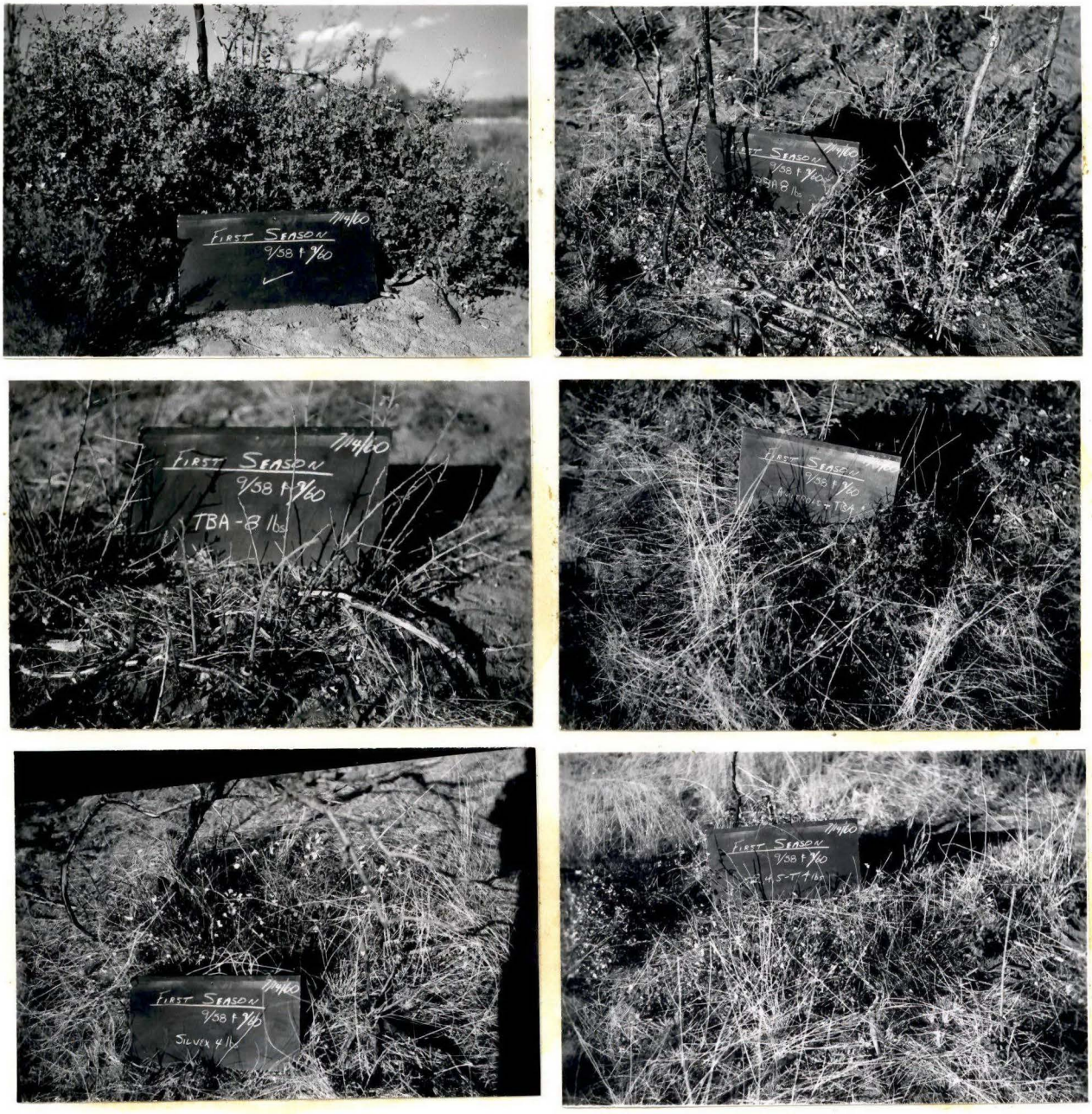


Figure 1. Pictures taken in July of 1960 of fire sprouts of turbinella oak treated with herbicides as labelled in September of 1958, 1959, and 1960.

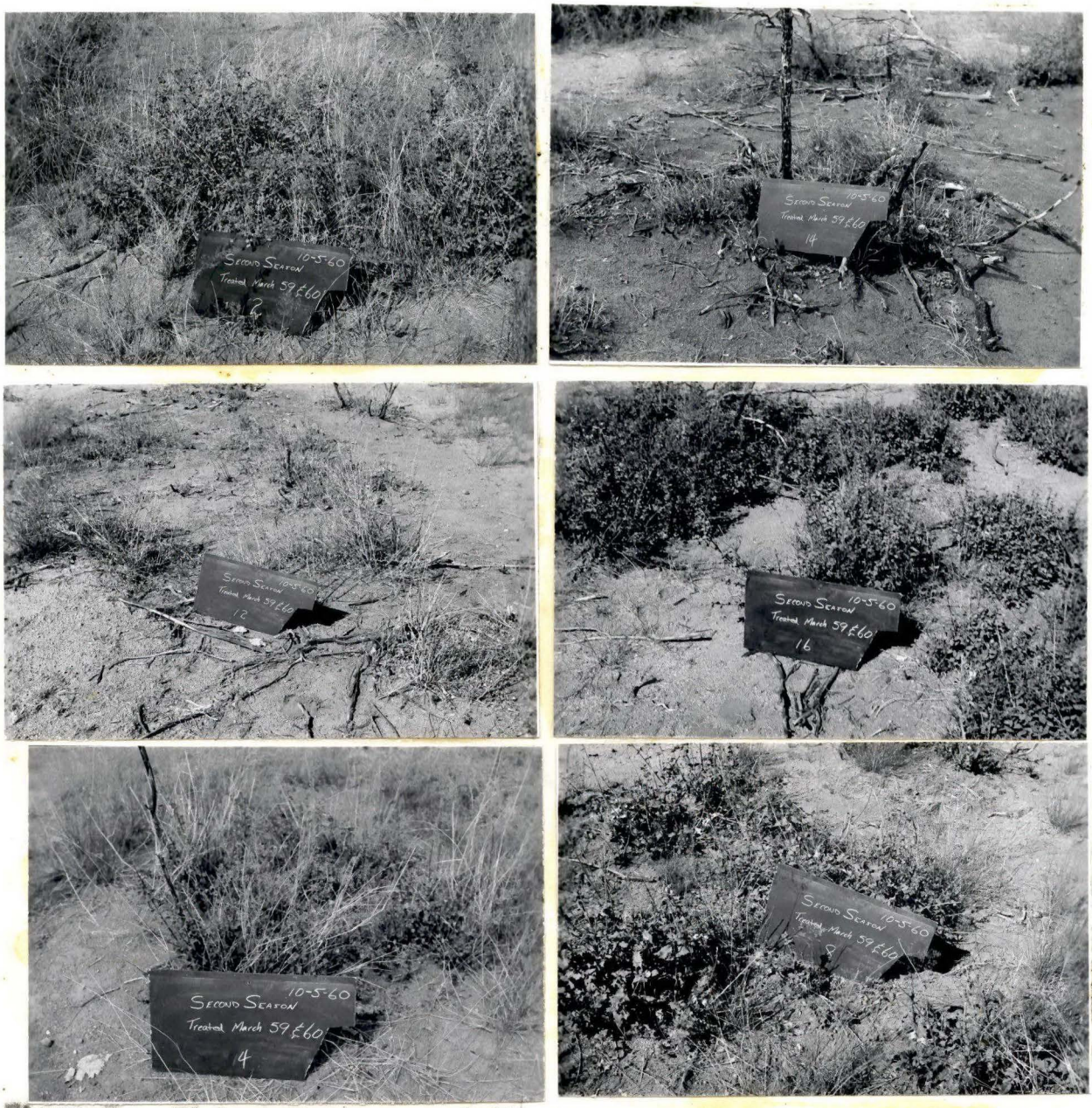


Figure 2. Pictures taken on 10/5/60 of oak sprouts treated in March of 1959 and 1960. From left to right - upper; check, TBA 8 lb. - middle; 2,3,6-TBA + amitrole 6 + 2 lb., 2,3,6-TBA 8 lb - lower; 2,4,5-T 4 lb., Silvex 4 lb.

normal tissue. There were no formative effects or other growth aberations in evidence. However, these herbicides did not injure the grass and did injure the turbinella oak. Periodic spraying with 2,4,5-T or silvex of a burned and reseeded area could be expected to at least greatly delay the time when the recovery of the brush species would dominate the site to the exclusion of the grasses.

Experiment Number 2

Title - Comparison of several formulations of 2,4,5-T and silvex for the control of turbinella oak.

Background - Silvex and 2,4,5-T have been shown to be among the more active herbicides tested for the control of turbinella oak. Applications of these compounds have resulted in good topkill of oak, but sprouting of the plant from the crown area and unkilled stem tissue has not been prevented. Data regarding which of these two compounds is the more effective on turbinella oak has been conflicting.

Most experiments with these herbicides have been carried out with standard low volatile esters of these herbicides in an oil/water emulsion. This test was designed to compare three formulations of low volatile esters and the amine salts of 2,4,5-T and silvex. These formulations are: oil in water emulsion, water in oil emulsion, and Dow Chemical's

forron formulation in water. The forron product was formulated to give control equal to the oil in water emulsion when applied in water alone. Since turbinella oak occurs in mountainous, often remote areas, it would be a distinct advantage to eliminate the oil from the spray mixture.

Objectives - The objectives of this test were:

1. To compare 2,4,5-T with silvex.
2. To compare two and four pounds per acre of each herbicide.
3. To compare the oil in water, water in oil, forron, and amine salt formulations.

Materials and Methods - Zero, two and four pounds per acre of 2,4,5-T and silvex were applied on May 20, 1959 as the forron and oil in water emulsion of low volative esters and as amine salts. Attempts to apply the water in oil (invert) emulsions were abandoned after the spray mixture repeatedly thickened to the point where it would not flow through the application equipment. The o/w emulsion was applied in a 1:7 oil water mixture while the forron and amine formulations were applied in water. The plots were 25 X 50 feet and arranged in four replications of a randomized block design.

The treatments were delivered from a 25 foot boom at 30 psi and 20 gpa. The weather was cloudy with the temperature

in the seventies and an 8-10 mph wind. The oak was growing actively.

The plots were retreated with the same treatments on May 25, 1960. Again the weather was cloudy, with the temperature in the seventies. The wind was blowing at approximately 10-12 mph. Turbinella oak was growing actively.

Results and Discussion - The results of this test are shown in Table 5. The analysis of variance (Appendix Table 3) shows that silvex was significantly more effective than 2,4,5-T at both dates of evaluation. This superiority of silvex has been generally true in these investigations. Greenhouse studies on oak seedlings (conducted by E. A. Davis, ARS) have shown 2,4,5-T to be superior as have some field evaluations. Silvex seemed to result in a slower, more chronic type of injury than did 2,4,5-T. Thus, premature observations might well show 2,4,5-T to be more active when actually it is only faster acting. This theory, if true, would not explain why 2,4,5-T is clearly superior in the greenhouse. It has been suggested that silvex shows up better than 2,4,5-T with repeat applications because silvex killed less tissue with the initial treatment. The theory was that the silvex treated bush presented more live tissue as a "target" for spray material at the second application than did the more necrotic bush initially treated with 2,4,5-T.

Table 5. Percent apparent kill of turbinella on plots treated 5-20-59 and retreated 5-25-60 with three formulations of 2,4,5-T and silvex.

| Treatment | Formulation | lbs/A | Percent Apparent Kill | | | |
|---|---|---|---|---|---|---|
| | | | Evaluated 5-24-60 | Treatment Mean | Evaluated 10-25-60 | Treatment Mean |
| 2,4,5-T | o/w emulsion(1:7) | 0 | 2.5 | | 5.0 | |
| | | 2 | 10.5 | | 37.5 | |
| | | 4 | 30.0 | 14.3 | 68.7 | 37.0 |
| 2,4,5-T | amine salt in water | 0 | 3.2 | | 4.2 | |
| | | 2 | 12.5 | | 33.7 | |
| | | 4 | 17.5 | 11.1 | 33.7 | 23.8 |
| 2,4,5-T | "Forron" in water | 0 | 2.2 | | 6.0 | |
| | | 2 | 4.7 | | 66.2 | |
| | | 4 | 27.5 | 11.4 | 87.5 | 53.2 |
| Silvex | o/w emulsion(1:7) | 0 | 7.2 | | 5.5 | |
| | | 2 | 26.2 | | 70.0 | |
| | | 4 | 25.0 | 19.4 | 76.2 | 50.5 |
| Silvex | amine salt in water | 0 | 5.5 | | 6.2 | |
| | | 2 | 18.7 | | 46.2 | |
| | | 4 | 23.7 | 15.9 | 48.7 | 33.7 |
| Silvex | "Forron" in water | 0 | 5.0 | | 6.7 | |
| | | 2 | 23.7 | | 67.5 | |
| | | 4 | 31.2 | 19.9 | 88.7 | 54.2 |

In this test, however, the evaluations taken on 5-24-60 were made just prior to the second application so they could not be influenced by retreatment effects.

It is possible that this discrepency between greenhouse and field tests has been due to the treatment of nature plants in the field while greenhouse tests have been carried out on seedlings.

The Duncan multiple range tests showed that two pounds of herbicide was significantly better than the check, and that four pounds of herbicide was significantly better than two.

At the time of the 5-24-60 evaluation there was no significant differences among the amine salt and the two low volatile ester formulations. The 10-25-60 evaluation (after retreatment) showed the two low volatile esters to be superior to the amine salt (Figure 3).

Experiment Number 3

Title - Effect on Quercus turbinella of various herbicides applied to the soil in a granular or pelleted form.

Background - Control of turbinella oak resulting from foliar herbicidal applications has been generally disappointing. Although some measure of topkill is obtained with foliar sprays, the plant always sprouts from stem or crown tissue at or below

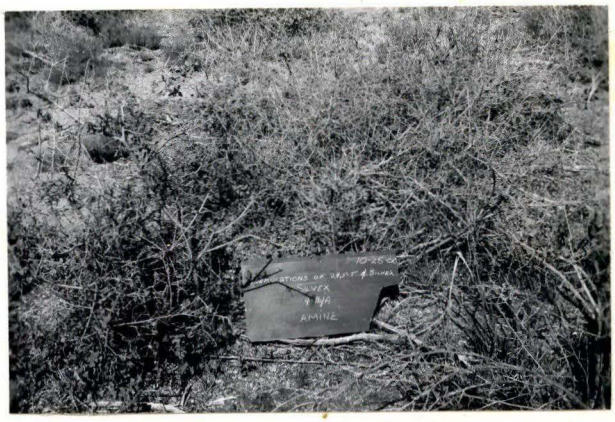

Figure 3. Pictures taken on 10-25-60 after treatment in the spring of 1959 and 1960 with several formulations of 2,4,5-T and silvex. Treatments as labelled on photos.

the soil surface. No sprouting of root tissue has been observed. Some method must be devised to impair the sprouting of this plant if control is to be effected with the herbicides now at hand.

The leaching of soil applied herbicides into the root zone followed by absorption by the roots of the plant offers a possible method of getting herbicides into the below ground portions of the plant where the sprouting problem exists.

Once applied, the herbicide is dependent on rainfall for leaching into the soil where it may be picked up by the plant. While on the soil surface the herbicide maybe subjected to loss due to photoinactivation, volatilization, and heat decomposition. Thus the herbicide should be leached into the soil as quickly as possible. In the semi-arid climate of Arizona it is only possible to apply the herbicides during or just prior to one of the two expected rainy seasons.

All granular or pelleted treatments in these tests were applied in December or July which is the first month of the expected winter and summer rainy seasons.

Objectives - The objectives of this experiment are to provide information relative to the use of granular and pelleted herbicides for the control of turbinella oak. These experiments were designed to provide information on:

1. Relative effectiveness of various herbicides for the control of turbinella oak.
2. Approximate application rate necessary for control.
3. Susceptibility of chaparral species to pelleted and granular applications of herbicides.
4. A comparison of applications made prior to summer and winter rainy seasons.
5. Any interaction which may exist between season of applications and herbicides.

Materials and Methods - The following treatments were applied at 4, 8, and 16 pounds active ingredient per acre on December 22 and 23, 1958.

| Herbicide | Form | Concentration (%) |
|---|---|---|
| check | - | - |
| 2,4,5-T LVE | granular | 12.7 |
| 2,4-D LVE | granular | 12.8 |
| Silvex LVE | granular | 12.9 |
| Monuron-TCA | granular | 22.0 |
| Monuron | pelleted | 25.0 |
| Fenuron | pelleted | 25.0 |
| 2,3,6-TBA (acid) | granular | 25.0 |
| 2,3,6-TBA (amine) | granular | 12.4 |
| Simazine | granular | 8.5 |

All formulations were obtained from commercial sources except the phenoxy derivatives and the amine salt of 2,3,6-TBA. These compounds were impregnated on 15/30 mesh attaclay (Fuller's earth) by addition of the liquid formulation to the granular carrier while the latter was tumbling in a small cement mixer. The tumbling was continued until the attaclay appeared to uniformly wetted. The concentration of the mixture was then calculated from the known weight of herbicide added and the weight of the dried herbicide-attaclay complex.

The herbicides were applied by hand broadcasting to 38 X 38 foot plots arranged in three replications of split plot experimental design. A 15 foot isolation strip was left between plots.

Soil samples were taken in the 16 pound per acre monuron and fenuron plots along with the corresponding check plots in December of 1960. These samples were taken of each six inch depth zone down to a depth of 48 inches. The sampling was accomplished with a post hole digger. Each six inch increment of soil was composited in a large bucket and throughly mixed. Three one pint samples were then taken of the soil composited from each depth zone.

It was realized that some contamination of the lower samples by soil dropping from above would be inevitable.

However, the amount of soil composited from each depth zone amounted to nearly 170 cubic inches so the slight amount of contamination was considered relatively unimportant.

A bio-assay is planned for the soil samples.

A similar test was applied to three replications of 35 x 40.8 foot plots arranged in a split plot field design on July 13, 1959. An isolation strip of 15 feet was left between plots and 5 foot isolation strips between sub-plots. The applications were made as described in the December, 1958 experiment.

Following is a list of herbicides which were applied:

| Herbicide | Form | Concentration(%) | Pound active Per acre |
|---|---|---|---|
| check | - | - | - |
| 2,4,-D | granular | 20.0 | 6, 12, and 24 |
| 2,4,5-T | granular | 20.0 | 6, 12, and 24 |
| 2,3,6-TBA (acid) | granular | 25.0 | 4, 8, and 16 |
| 2,3,6-TBA (amine) | granular | 10.9 | 4, 8, and 16 |
| Femuron-TCA | granular | 22.0 | 4, 8, and 16 |
| Monuron-TCA | granular | 22.0 | 4, 8, and 16 |
| Femuron | pelleted | 25.0 | 4, 8, and 16 |
| Monuron | pelleted | 25.0 | 4, 8, and 16 |

Soil samples were taken from the 16 lb/acre femuron, monuron, femuron-TCA, and monuron-TCA plots to a depth of 42 inches in the

manner described in the previous experiment. These samples will also be subjected to a bio-assay.

All plots in both tests were reseeded with Lehman's lovegrass at the rate of 2 lbs/acre in July 1960. Due to lack of rainfall and poor distribution of that rainfall that did occur there was no grass established in check or treated plots.

Results and Discussion - The results of these experiments (Tables 6 and 7) must be considered preliminary nearly two years after the initial application. The plants on many of the plots are still alive but showing severe symptoms of injury. This is particularly true on those plots treated with herbicides from the substituted urea family of compounds and, to a lesser extent, on those plots treated with benzoic acid derivatives.

Fenuron has been consistently the most effective herbicide in these tests. By the spring of 1960 the oak on those plots treated with 16 lbs/acre of fenuron was nearly 100 percent topkilled. However, with the start of the spring growing season the plants produced a number of small sprouts from the crown area. The leaves on these sprouts developed symptoms, the sprouts defoliated, and most of them were killed. By October 1960, the oak on these plots was apparently dead (Figure 4). The oak on the 8 lb/acre fenuron treatments in

Table 6. Percent apparent of turbinella oak kill on two evaluation dates after treatment in December 1958 with three rates of various pelleted or granular herbicides.

| Treatment | Lbs/A | Percent Apparent Kill | | | |
|---|---|---|---|---|---|
| | | Evaluated 7-14-60 | Treatment Mean | Evaluated 10-25-60 | Treatment Mean |
| Check | 0 | 2 | | 3 | |
| | 0 | 2 | 2 | 7 | 5 |
| | 0 | 2 | | 5 | |
| 2,4-D | 4 | 2 | | 10 | |
| | 8 | 2 | 2 | 8 | 9 |
| | 10 | 3 | | 9 | |
| 2,4,5-T | 4 | 2 | | 13 | |
| | 8 | 3 | 2 | 8 | 10 |
| | 16 | 2 | | 8 | |
| Silvex | 4 | 1 | | 5 | |
| | 8 | 4 | 3 | 6 | 5 |
| | 16 | 2 | | 4 | |
| Fenuron | 4 | 53 | | 68 | |
| | 8 | 67 | 69 | 86 | 84 |
| | 16 | 88 | | 98 | |
| Monuron | 4 | 17 | | 38 | |
| | 8 | 63 | 54 | 78 | 69 |
| | 16 | 83 | | 92 | |
| Monuron-TCA | 4 | 13 | | 17 | |
| | 8 | 23 | 25 | 33 | 34 |
| | 16 | 40 | | 53 | |
| 2,3,6-TBA (acid) | 4 | 33 | | 33 | |
| | 8 | 47 | 47 | 40 | 46 |
| | 16 | 60 | | 65 | |
| Simazine | 4 | 2 | | 4 | |
| | 8 | 3 | 2 | 5 | 5 |
| | 16 | 2 | | 5 | |
| 2,3,6-TBA (amine) | 4 | 23 | | 23 | |
| | 8 | 33 | 35 | 37 | 35 |
| | 16 | 50 | | 47 | |

Table 7. Percent apparent kill of turbinella oak on two evaluation dates after treatments in July of 1959 with three rates of various granular or pelleted herbicides.

| Treatment | Lbs/A | Percent Apparent Kill | | | |
|---|---|---|---|---|---|
| | | Evaluated 7-15-60 | Treatment Mean | Evaluated 10-25-60 | Treatment Mean |
| Check | 0 | 8 | | 8 | |
| | 0 | 3 | 5 | 8 | 7 |
| | 0 | 3 | | 6 | |
| 2,3,6-TBA (amine) | 4 | 30 | | 30 | |
| | 8 | 40 | 41 | 37 | 39 |
| | 16 | 53 | | 52 | |
| 2,3,6-TBA (acid) | 4 | 33 | | 22 | |
| | 8 | 46 | 44 | 32 | 32 |
| | 16 | 56 | | 42 | |
| Monuron | 4 | 27 | | 43 | |
| | 8 | 47 | 46 | 68 | 65 |
| | 16 | 63 | | 83 | |
| Fenuron | 4 | 37 | | 60 | |
| | 8 | 50 | 50 | 73 | 75 |
| | 16 | 63 | | 91 | |
| Monuron-TCA | 4 | 23 | | 15 | |
| | 8 | 33 | 39 | 30 | 40 |
| | 16 | 60 | | 76 | |
| Fenuron-TCA | 4 | 17 | | 20 | |
| | 8 | 30 | 37 | 38 | 47 |
| | 16 | 63 | | 81 | |
| 2,4-D | 4 | 3 | | 8 | |
| | 8 | 6 | 14 | 13 | 12 |
| | 16 | 23 | | 15 | |
| Silvex | 4 | 4 | | 6 | |
| | 8 | 5 | 7 | 8 | 11 |
| | 16 | 11 | | 18 | |

this test retained some live branches, but their leaves all looked promising with a significant amount of topkilling present and all remaining leaves showing symptoms of fenuron injury. Monuron was similar to, but slightly less effective, than fenuron.

The high rates of fenuron and monuron (Figure 4) had killed essentially all grassy and herbaceous plants on the plots with the exception of a species of spurge (Euphorbia sp.). Several other secondary species of brush including mountain mahogany (Cercocarpus montanus), ceanothus (Ceanothus greggii), squawberry (Rhus trilobata), cliff rose (Cowania mexicana), and catclaw mimosa (Mimosa biuncifera) had been killed or severely damaged. Catclaw mimosa, the least desirable species, appeared to be the most resistant of the secondary brush species. These species were present only in scattered spots and valid observations on their susceptibility to the various herbicides was not possible to obtain.

Snakeweed (Gutierrezia sarothrae), a half-shrub present on nearly all plots and of common occurance in the Arizona chaparral, was completely eliminated with 16 lbs. of fenuron, a few plants remained at 8 lbs. and 4 lbs. killed only about 50 percent of the snakeweed.

The almost complete loss of grass from fenuron treatments would be a serious block to its popular acceptance as a chaparral

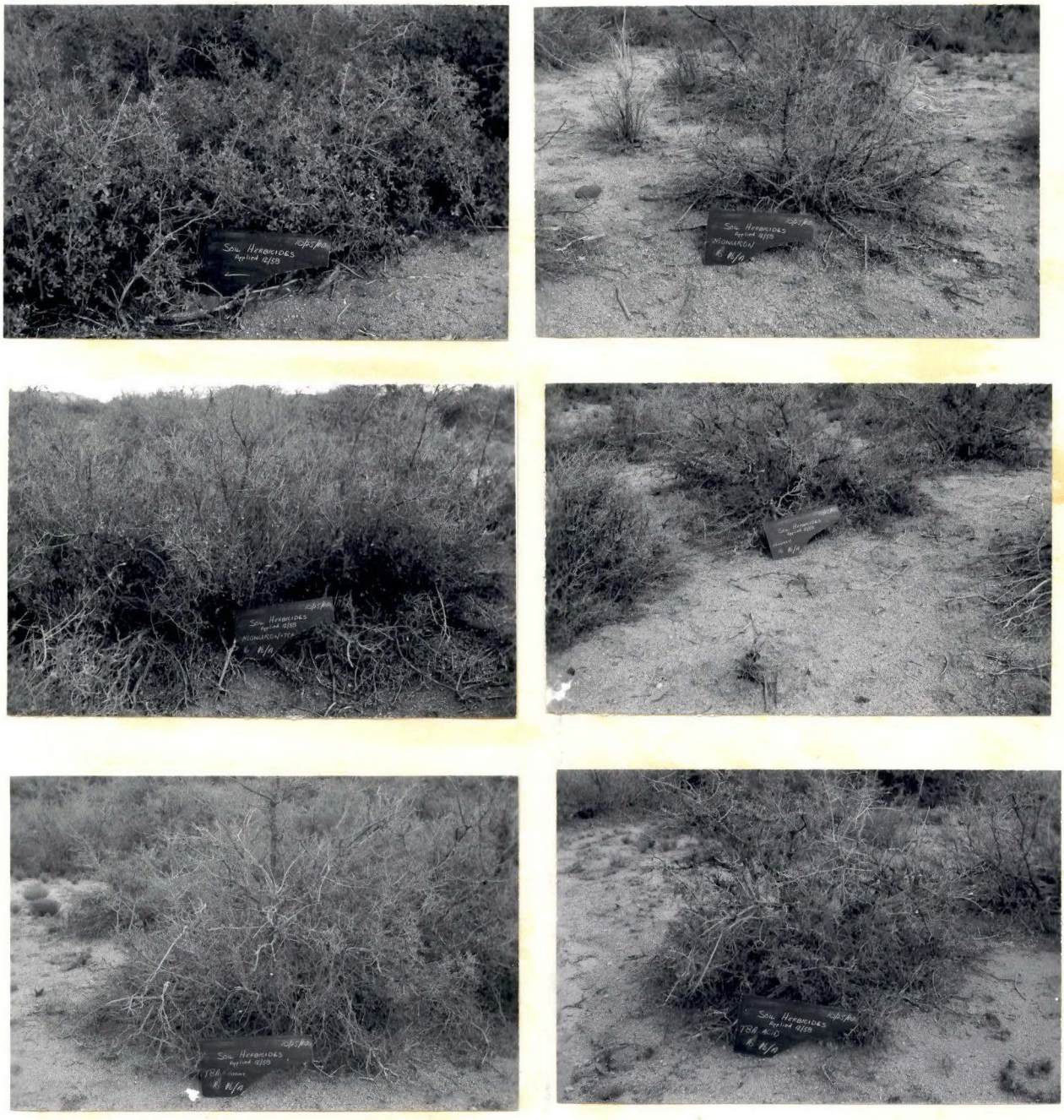

Figure 4. Pictures taken in October of 1960 of plots treated in December of 1958 with various granular or pelleted herbicides. Treatments as labelled on photos.

control treatment. It will be necessary to demonstrate conclusively the length of time this herbicide will persist in the soil and prevent reseeding of the treated areas. The reseeding attempts during the summer of 1960 were a failure, however, reseeding will be attempted again in 1961 and the periodic bio-assays of the soil profile will furnish some information as to the persistance of this herbicide in Arizona chaparral soils.

Another series of herbicides that showed some promise in these tests were the two benzoic acid derivatives. The amount of topkilling was less than that obtained with monuron and fenuron, but the regrowth of the oak on the benzoic acid treated plots was badly malformed and much of it died. However, comparison of the two dates of evaluation on these tests (Tables 6 and 7) showed that the oak was recovering from the treatments. Some of the regrowth in the fall of 1960 was not malformed and grew in a normal fashion. These herbicides were not so lethal to the grass as was fenuron. However, they apparently did not persist long enough to control the oak.

Monuron-TCA was significantly less effective than benzoic acid (Table 8). The other herbicides in the December, 1958 tests were 2,4,-D, 2,4,5-T, silvex, and simazine. These herbicides were not significantly different from the check plots (Table 8).

The mean percent apparent kill of those treatments common to both dates of applications was calculated. The mean for the December, 1958 treatments was 35.9, the mean for the July, 1959 treatments was 35.1. If a difference exists between winter and fall application of soil herbicides these tests failed to detect it. There were differences in the relative effectiveness of the individual treatments (Tables 8 and 9, Figures 4 and 5) but it was impossible to detect any overall difference between the two dates of application. The July, 1959 test only serves to substantiate the differences among herbicides that were shown in the earlier test.

Experiment Number 4

Title - Chemical desiccation of turbinella oak.

Background - Prescribed burning alone or followed by chemical treatment may prove to be a valuable tool for the control of Arizona chaparral species. Prescribed burning followed by reseeding to Lehman's lovegrass has already been shown to be a workable practice for the improvement of chaparral rangeland. This treatment applied to a section of chaparral range resulted in an estimated five-fold increase in carrying capacity.

Controlled or prescribed burning in Arizona chaparral is either difficult or dangerous, depending on weather and

Table 8. Duncan multiple range tests on treatment means of percent apparent kill of turbinella oak on two dates after treatment in July of 1959 with three rates of various pelleted or granular herbicides.

| Evaluation Date | Treatment Means* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 7-14-60 | Check | 2,4-D | 2,4,5-T | Simazine | Silvex | Monuron-TCA | 2,3,6-TBA (amine) | 2,3,6-TBA (acid) | Monuron | Fenuron |
| | 2 | 2 | 2 | 2 | 2 | 25 | 35 | 47 | 54 | 69 |
| 10-25-60 | Check | Simazine | Silvex | 2,4-D | 2,4,5-T | Monuron-TCA | 2,3,6-TBA (amine) | 2,3,6-TBA (acid) | Monuron | Fenuron |
| | 5 | 5 | 5 | 9 | 10 | 34 | 35 | 46 | 69 | 84 |

* All means not underlined by the same line differ at the 5 percent probability level.

Table 9. Duncan multiple range tests on treatment means of percent apparent kill of turbinella oak evaluated on two dates after treatment in July of 1959 with three rates of various pelleted or granular herbicides.

| Evaluation Date | Treatment Means* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 7-15-60 | Check | Silvex | 2,4-D | Fenuron-TCA | Monuron-TCA | 2,3,6-TBA (amine) | 2,3,6-TBA (acid) | Monuron | Fenuron |
| | 5 | 7 | 14 | 37 | 39 | 41 | 44 | 46 | 50 |
| 10-25-60 | Check | Silvex | 2,4-D | 2,3,6-TBA (acid) | 2,3,6-TBA (amine) | Monuron-TCA | Fenuron-TCA | Monuron | Fenuron |
| | 7 | 11 | 12 | 32 | 39 | 40 | 47 | 65 | 75 |

* All means not underlined by the same line differ at the 5 percent probability level.

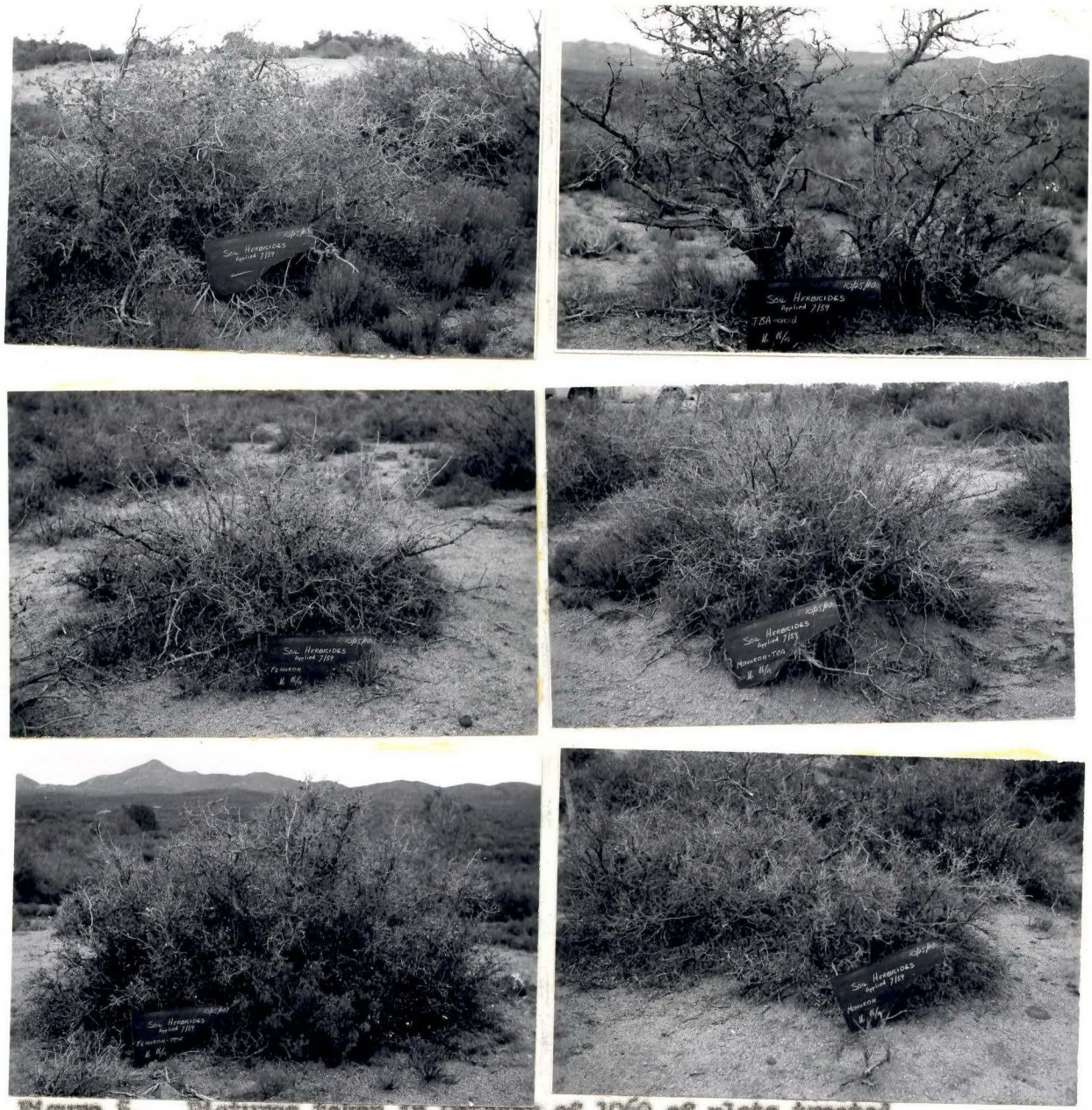


Figure 5. Pictures taken in October of 1960 of plots treated in July of 1959 with various granular or pelleted herbicides. Treatments as labelled on photos.

fuel moisture conditions at the time of burning. Under conditions of low humidity, low fuel moisture, high temperature and sufficient wind velocity to "carry" the fire the chaparral will burn readily, but there is danger of a wildfire. The costs of fire lanes, men, and protective equipment are prohibitive under these conditions of high flamability. Under conditions where the wildfire hazard is not great the chaparral will burn only with difficulty.

Through chemical desiccation of chaparral it may be possible to lower the fuel moisture content of chaparral to the point where the pretreated area will burn readily under conditions where the danger of wildfire is greatly reduced. If the area of the prescribed burn is large it might be possible to pretreat and burn wide fire lanes under conditions of low wildfire hazard. The major portion of the prescribed burn could then be applied when the chaparral would burn without pretreatment.

Still a third possibility is that the pretreatment might have an inhibitory effect on sprouting following the burn.

Objectives - The objective of this test is to evaluate the effect of various herbicides on the fuel moisture content of turbinella oak leaves and small stems. These experiments were designed to provide information pertaining to:

1. The effectiveness of various compounds in reducing the fuel moisture of turbinella oak.
2. Minimum effective application rates.
3. Length of time required for maximum expression of chemical activity.
4. The effect of season of application upon rate and extent of desiccation of oak.

Materials and Methods - One and two lbs/acre of 2,4-D, 2,4,5-T and silvex were applied along with two and four lbs/acre of DNBP on September 19, 1960. The treatments were made at 30 psi and 20 gpa from a $CO_2$ pressured back-pack sprayer to single bush plots arranged in four replications of a randomized block experimental design.

Fuel moisture samples were taken one, four, and eight weeks following treatment. A light rain occured four days prior to the four week sampling date.

The samples were taken by clipping off small twigs on four sides of each bush. The leaves were stripped off of each clipped twig, composited in a small bottle and the bottle immediately capped. The twigs were similarly placed in a second bottle. The samples were returned to the laboratory, weighed and oven-dried at 105° C. for approximately 24 hours. The samples were then re-weighed, and the weight loss recorded. The weight loss was expressed as fuel moisture on an oven dry basis.

Results and Discussion - The treatments had no effect on the fuel moisture of small twigs (Table 10). Due to a rain just prior to the four week sampling date, the twigs were higher in moisture at the four and eight week sampling dates than they were prior to treatment.

All herbicidal applications lowered the fuel moisture of leaves (Table 11). DNBP resulted in the most rapid desication and this treatment was less affected by the rain than the phenoxy treatments. DNBP did not lower the moisture quite as low as did the phenoxy herbicides in spite of application at a higher rate. DNBP has the added disadvantage of being a contact herbicide with no opportunity for any systemic herbicidal effects following a fire.

There was little difference in total effect between 2,4,5-T and silvex except for the more rapid activity displayed by the 2,4,5-T. Both herbicides resulted in essentially the same fuel moisture reduction eight weeks after treatment. The increase in available moisture following the rain influenced the drying of the silvex treatments profoundly while affecting the 2,4,5-T treated bushes only slightly. The 2,4,5-T treated leaves were evidently already necrotic and unable to absorb and/or retain moisture.

Table 10. Fuel moisture expressed as percent of oven-dry weight of small twigs of turbinella oak at several intervals after treatment with various herbicides on September 9, 1960.

| Herbicide | Rate | Weeks After Treatment 0 % Fuel Moisture | 1 % Fuel Moisture | 4 % Fuel Moisture | 8 % Fuel Moisture |
|---|---|---|---|---|---|
| 2,4-D | 1 | 64 | 70 | 89 | 74 |
| | 2 | 63 | 71 | 95 | 76 |
| 2,4,5-T | 1 | 67 | 69 | 91 | 79 |
| | 2 | 59 | 66 | 94 | 81 |
| Silvex | 1 | 63 | 69 | 88 | 75 |
| | 2 | 62 | 69 | 94 | 66 |
| DNBP | 2 | 68 | 65 | 84 | 71 |
| | 4 | 64 | 69 | 89 | 72 |
| Oil Check | 0 | 63 | 64 | 79 | 64 |
| Check | 0 | 64 | 61 | 74 | 65 |

Table 11. Fuel moisture expressed as percent of oven-dry weight of leaves of turbinella oak at several intervals after treatment with various herbicides on September 9, 1960.

| Herbicide | Rate | Weeks After Treatment 0 % Fuel Moisture | 1 % Fuel Moisture | 4 % Fuel Moisture | 8 % Fuel Moisture |
|---|---|---|---|---|---|
| 2,4-D | 1 | 83 | 71 | 79 | 36 |
| | 2 | 86 | 52 | 45 | 23 |
| 2,4,5-T | 1 | 87 | 61 | 54 | 28 |
| | 2 | 87 | 49 | 23 | 14 |
| Silvex | 1 | 82 | 79 | 84 | 21 |
| | 2 | 84 | 49 | 55 | 13 |
| DNBP | 2 | 85 | 39 | 36 | 28 |
| | 4 | 83 | 37 | 29 | 29 |
| Oil Check | 0 | 87 | 80 | 96 | 97 |
| Check | 0 | 86 | 82 | 137 | 106 |

Both 2,4,5-T and silvex were more effective than 2,4-D. It is not known if the additional drying obtained with 2,4,5-T and silvex is of sufficient importance in burning to offset their increased cost.

An experiment where fire is actually used on pre-treated plots is contemplated in cooperation with the U. S. Forest Service. Herbicides will be among the pre-treatments applied to various plots. In this experiment we hope to find out if the amount of drying on leaves is sufficient to enable burning under low fire hazard conditions. With the fuel moisture still high in the twigs the fire may just flash off the leaves without igniting the twigs.

Experiment Number 5

Title - Influence of application date on control of turbinella oak with low volatile esters of 2,4,5-T and silvex.

Background - Foliar applications of herbicides have not resulted in adequate control of turbinella oak. Varying amounts of topkilling have resulted but sprouting always occurs.

If control is to obtained with the herbicides now at hand some method must be devised to impair this sprouting. A possibility is some period in the growth cycle of this plant when susceptibility to, or translocation of, the herbicide is at a maximum.

Objectives - The objective of this experiment was to explore the spring growing season for a period of maximum susceptibility of turbinella oak to 2,4,5-T or silvex. A further objective is to compare these two herbicides at various rates of application.

Materials and Methods - Zero, two, four and eight lbs.acre of 2,4,5-T and silvex were applied to five replications of single bush plots at various dates in the spring of 1959. The treatments were applied emulsified in water at 20 gpa from a six foot boom. The herbicides were applied on the following dates.

1. March 12, 1959
2. April 2, 1959
3. April 10, 1959
4. April 21, 1959
5. April 24, 1959
6. May 1, 1959
7. May 8, 1959
8. May 26, 1959

Phenological and climatological observations are available for each application date.

Results and Discussion - The results of a July 14, 1960 observation (Table 12) indicate there was no differences among

Table 12. Percent apparent kill of turbinella oak as evaluated in July, 1960 on plots treated with 3 rates of 2,4,5-T and silvex at various dates in the spring of 1959.

| Herbicide | Rate | Date of Treatment | | | | | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 3-12-59 | 4-2-59 | 4-10-59 | 4-17-59 | 4-24-59 | 5-1-59 | 5-8-59 | 5-27-59 | |
| | | Percent Apparent Kill | | | | | | | | |
| 2,4,5-T | 0 | 4 | 3 | 5 | 3 | 2 | 4 | 4 | 3 | 3.5 |
| | 2 | 28 | 36 | 20 | 22 | 18 | 14 | 22 | 14 | 21.7 |
| | 4 | 22 | 28 | 20 | 18 | 24 | 17 | 28 | 14 | 21.4 |
| | 8 | 30 | 26 | 34 | 22 | 34 | 34 | 42 | 36 | 32.2 |
| Silvex | 0 | 3 | 5 | 3 | 5 | 3 | 3 | 7 | 6 | 4.4 |
| | 2 | 26 | 24 | 22 | 18 | 22 | 18 | 24 | 22 | 22.0 |
| | 4 | 34 | 20 | 26 | 28 | 34 | 26 | 38 | 18 | 28.0 |
| | 8 | 44 | 34 | 46 | 36 | 36 | 42 | 38 | 38 | 39.2 |
| Mean | | 23.9 | 22.0 | 22.0 | 19.0 | 21.6 | 19.7 | 25.4 | 18.9 | |

the various application dates. Silvex was significantly more effective than 2,4,5-T. All rates of application were better than the check and eight pounds of herbicide was significantly better than two pounds. There was no difference between two and four pounds or four and eight pounds of herbicide.

Experiment Number 6

Title - Number of reapplications of 2,4,5-T and 2,3,6-TBA (amine salt) necessary for control of fire sprouts of turbinella oak.

Background - Single or two annual applications of phenoxy herbicides have not been sufficient to control turbinella oak. However, topkill has been obtained with a single application. If the plant is topkilled frequently enough over a long enough period of time, the result must eventurally be the death of the plant even without the systemic action of the herbicide. It is of at least academic interest to determine just how many retreatments will be required for complete control of this species.

Trichlorobenzoic acid derivatives have not resulted in the rapid necrosis of leaves and stems that has been observed with the phenoxy herbicides. One year following treatment of oak with benzoic acids the oak sprouts had grown very little and the growth that was evident was malformed and often dead or dying. It is also of interest to determine the effect of repeated applications of benzoic acids to turbinella oak.

Objectives - To determine how long annual and semi-annual retreatments of 2,4,5-T and 2,3,6-TBA must be continued to effect complete control of turbinella oak. A second objective is to compare 2,4,5-T and 2,3,6-TBA at equal rates under these conditions.

Materials and Methods - The treatments consist of a two pound per acre rate of 2,4,5-T and 2,3,6-TBA applied in the spring, in the fall, and both spring and fall until such time as complete control of fire sprouts of turbinella oak has been accomplished.

To date treatments have been applied on 5-8-59, 9-24-59, 5-12-60 and 10-7-60. This results plots treated in the spring of 1959 and 1960, the fall of 1959 and 1960, and both spring and fall of 1959 and 1960 (total of four treatments). These treatments were applied to 25 X 50 foot plots in six replications of a randomized block experimental design.

The plot area was burned in June of 1958 and immediately reseeded to Lehman's lovegrass. An excellent stand of grass resulted from the seeding.

Results and Discussion - The results (Table 13) indicate that turbinella oak is able to withstand a burning and three applications of two pounds per acre of 2,4,5-T or 2,3,6-TBA within a period of 28 months. These evaluations did not take into consideration the reduction of canopy or suppression of

Table 13. Percent apparent kill of turbinella oak on two evaluation dates resulting from spring, fall, and both spring and fall applications of two pound per acre applications of 2,4,5-T and 2,3,6-TBA extending from the spring of 1959 through the fall of 1960.

| Herbicide | Rate, lb/A | Season of Treatment | Percent Apparent Kill | |
|---|---|---|---|---|
| | | | Evaluated 5-12-60 | Evaluated 10-3-60 |
| 2,4,5,-T | 2 | Spring | 27 | 5 |
| 2,4,5-T | 2 | Fall | 42 | 10 |
| 2,4,5-T | 2 | Spring & Fall | 62 | 30 |
| 2,3,6-TBA | 2 | Spring | 20 | 21 |
| 2,3,6-TBA | 2 | Fall | 9 | 9 |
| 2,3,6-TBA | 2 | Spring & Fall | 45 | 23 |
| Check | 0 | - | 2 | 1 |

growth of turbinella oak. The suppression of growth has been considerable (Figure 6). However, the amount of control or kill of oak was disappointing.

It will evidently require a great many treatments with these herbicides at these rates to completely kill turbinella oak. The recovery of oak from 62 percent apparent kill just prior to the spring of 1960 treatment to 30 percent in one growing season illustrates the reserves of this plant.

The statistical analysis (Table 14, Appendix Table 6) indicates that there is little consistent difference among the treatments. The applications made twice annualy always resulted in the better control, but these differences were not significant in some cases.

It appears that this study must run at least one more year before the differences in the treatments, if any, will become apparent.

Experiment Number 7

Title - The effectiveness of pelleted and granular applications of several herbicides, as influenced by leaching, on the control of turbinella oak.

Technical Personnel - E. A. Davis, Plant Physiologist and D. T. Lillie, Research Agronomist.

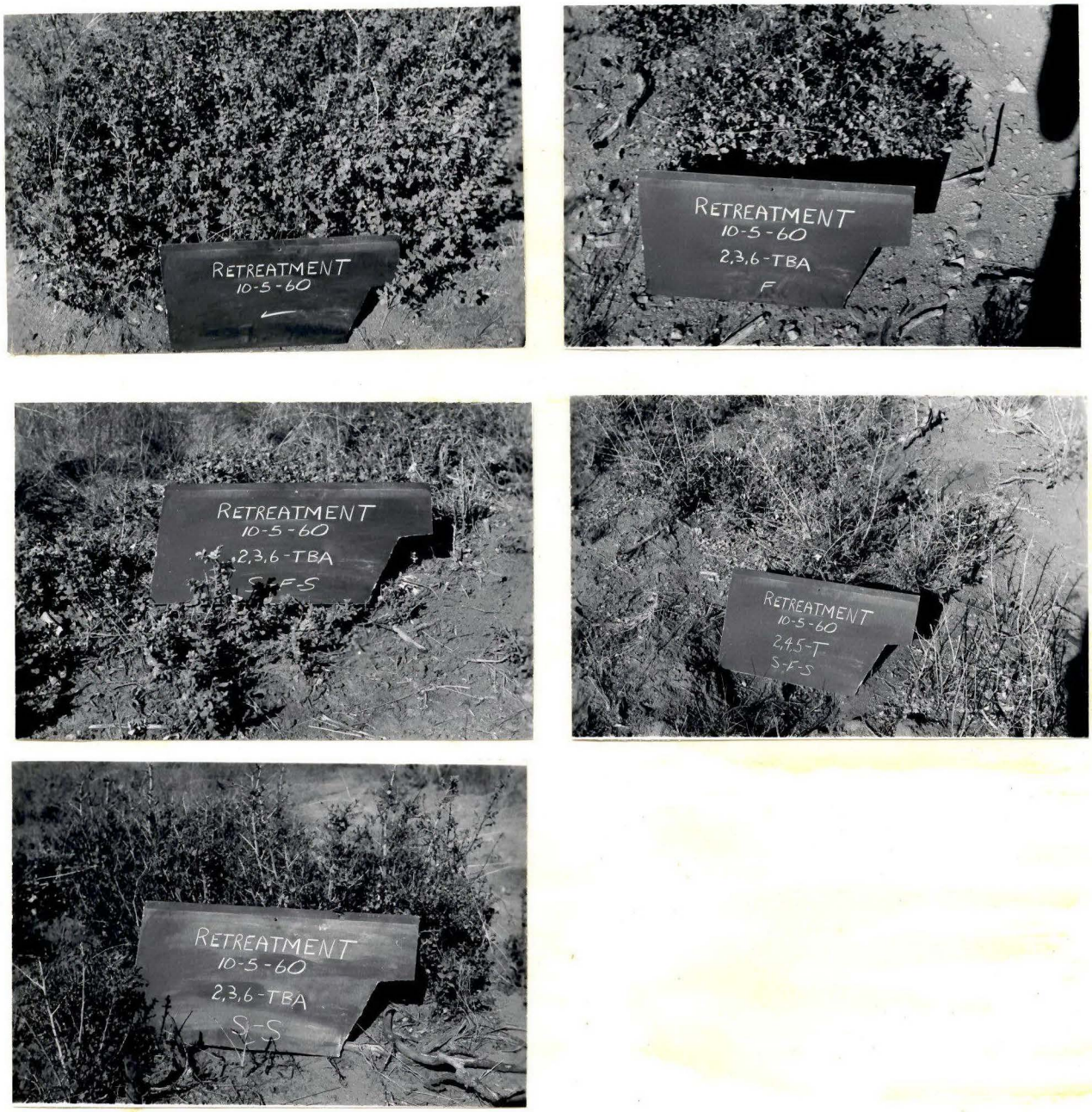


Figure 6. Pictures taken in October 1960 of plots treated as labelled. Treatments have been applied in the spring of 1959, fall of 1959, and spring of 1960.

Table 14. Duncan multiple range test on data resulting from two evaluations of spring (S), fall (F), and spring and fall (SF) applications of two pounds per acre of 2,4,5-T and 2,3,6-TBA extending from the spring of 1959 through the fall of 1960.

| Evaluation Date | Treatment Means* | | | | | | |
|---|---|---|---|---|---|---|---|
| 5-12-60 | Check | 2,3,6-TBA-F | 2,3,6-TBA-S | 2,4,5-T-F | 2,4,5-T-S | 2,3,6-TBA-SF | 2,4,5-T-SF |
| | 2 | 9 | 20 | 27 | 42 | 45 | 62 |
| 10-3-60 | Check | 2,4,5-T-S | 2,3,6-TBA-F | 2,4,5-T-F | 2,3,6-TBA-S | 2,3,6-TBA-SF | 2,4,5-T-SF |
| | 1 | 5 | 9 | 10 | 21 | 23 | 30 |

* All means not underlined by the same line differ at the 5 percent probability level.

Background - Foliar sprays with ground or aerial equipment have not resulted in adequate control of turbinella oak due to the fact that they have not prevented sprouting. Application of herbicides to the soil surface in granular or pelleted forms may be more effective in preventing sprouting of oak due to absorption by the root system of the plant. This puts the herbicide in the below ground portion of the plant where it must be if sprouting of this plant is to be controlled.

One of the major considerations concerning soil application of herbicides is the leaching of these herbicides into the root zone of the plant. The occurance of rainfall under the semi-arid conditions which obtain in the Arizona chaparral is at best a probability that rainfall will occur in the summer and in the winter. Either one or both of these rainy seasons may yield very little precipitation in a given year. Therefore, it is desirable to know just how much rainfall is necessary to leach the herbicides into the root zone of the plant. Such information would be valuable to assist in interpretation of data from large-scale field tests.

Objectives -

1. To determine the influence of soil applications of granular or pelleted herbicide formulations on turbinella oak in the field.

2. To compare various herbicides as to effectiveness for the control of oak.

3. To compare three rates of each herbicide.

4. To determine the effect of leaching upon the rate and extent of herbicidal action.

Materials and Methods - The following treatments were applied to three replications of single bush plots in a completely randomized block in August of 1959.

| Herbicide | Concentrate | Rate, lb/acre |
|---|---|---|
| Monuron | 25% pellets | 4, 8, and 16 |
| Fenuron | 25% pellets | 4, 8, and 16 |
| Monuron-TCA | 22% granular | 4, 8, and 16 |
| 2,3,6-TBA | 25% granular | 4, 8, and 16 |
| Fenac | 10% granular | 4, 8, and 16 |
| 2,4-D | 10% granular | 8, 16 and 32 |
| silvex | 10% granular | 8, 16 and 32 |

An area of 16 square feet around each bush was treated. A 4 X 4 foot galvanized iron frame was placed around each bush and the aliquot of herbicide applied within the frame. The leaching treatments were zero, two and four inches of water.

The water was hauled to the site in a tank truck (supplied by Arizona State University) and pumped out of the truck by a pump mounted on an Oliver OC-4 tractor. The water was measured

by a water meter (supplied by the Citrus Experiment Station, University of Arizona) on the discharge side of the pump. It was sprinkled on the plots to simulate rainfall and to aid in dissolving the pelleted and granular herbicides.

Results and Discussion - The occurance of rainfall since the time of treatment apparently masked any effect of the leaching treatments (Table 15). If there were any differences they appeared to correlate negatively with increasing amounts of leaching. This could mean that the herbicides had leached below the root zone of the plants. The soil was moist to a considerable depth at time of treatment so a relatively small amount of precipitation would leach the herbicide to an appreciable depth. The amount of rainfall since application is shown in Table 16.

Since rainfall occured immediately after the application of the treatments there was no opportunity for loss of the herbicide on the non-leached plots from volatility and other causes while the herbicide was on the soil surface.

The comparison between herbicides revealed that fenuron was the only effective herbicide in this test. Monuron and 2,3,6-TBA were far less effective on this small plot, single bush test, than they were on the larger plots previously reported. Evidently the size of the plots does not encompass

Table 15. Percent apparent kill of turbinella oak on two evaluation dates after treatment in August of 1959 with various rates of several granular or pelleted herbicides followed by leaching with zero, one, two, or four inches of water.

| Treatment | Rate, lb/A | Inches of Water | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 4 | 0 | 1 | 2 | 4 |
| | | Evaluated 4-14-60 | | | | Evaluated 8-19-60 | | | |
| | | Percent Apparent Kill | | | | | | | |
| Monuron | 4 | 2 | 2 | 2 | 2 | 3 | 2 | 0 | 2 |
| | 8 | 11 | 18 | 0 | 16 | 13 | 8 | 0 | 5 |
| | 16 | 2 | 11 | 23 | 61 | 23 | 10 | 20 | 20 |
| Fenuron | 4 | 54 | 81 | 69 | 23 | 5 | 23 | 11 | 10 |
| | 8 | 46 | 82 | 66 | 43 | 60 | 70 | 68 | 68 |
| | 16 | 82 | 64 | 66 | 76 | 92 | 76 | 83 | 91 |
| Monuron-TCA | 4 | 2 | 11 | 0 | 5 | 0 | 0 | 0 | 0 |
| | 8 | 10 | 23 | 5 | 10 | 3 | 7 | 0 | 0 |
| | 16 | 35 | 69 | 54 | 53 | 33 | 58 | 32 | 41 |
| 2,3,6-TBA | 4 | 41 | 3 | 15 | 15 | 54 | 3 | 0 | 0 |
| | 8 | 0 | 2 | 5 | 0 | 16 | 8 | 0 | 3 |
| | 16 | 38 | 30 | 46 | 0 | 39 | 48 | 43 | 7 |
| Fenac | 4 | 0 | 0 | 2 | 0 | 3 | 10 | 3 | 0 |
| | 8 | 2 | 3 | 13 | 2 | 15 | 10 | 33 | 7 |
| | 16 | 35 | 10 | 5 | 3 | 16 | 5 | 15 | 0 |
| 2,4-D | 8 | 0 | 10 | 0 | 2 | 5 | 8 | 0 | 0 |
| | 16 | 2 | 0 | 0 | 0 | 13 | 0 | 0 | 0 |
| | 32 | 2 | 3 | 5 | 5 | 0 | 2 | 3 | 0 |
| Silvex | 8 | 0 | 0 | 2 | 11 | 0 | 0 | 0 | 0 |
| | 16 | 0 | 0 | 0 | 2 | 0 | 0 | 7 | 0 |
| | 32 | 2 | 3 | 21 | 2 | 7 | 5 | 5 | 0 |
| Check | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| Mean | | 18 | 20 | 18 | 16 | 19 | 17 | 15 | 12 |

Table 16. Rainfall at site of granular-pelleted herbicide leaching experiment.

| Date | Cumulative Rainfall Since Previous Reading | Date | Cumulative Rainfall Since Previous Reading |
|---|---|---|---|
| 1959 | | 1960 | |
| 8-18 | 0.04 | 5-18,5-26 | 0.00 |
| 8-24 | 1.24 | 6-10 | 0.03 |
| 8-27 | 0.01 | 7-14 | 0.00 |
| 9-16 | 0.02 | 7-28 | 0.34 |
| 9-25 | 0.00 | 8-4 | 0.33 |
| 9-28 | 0.00 | 8-11 | 2.01 |
| 10-3 | 0.80 | 8-13 | 0.27 |
| 10-31 | 1.77 | 8-16 | 0.03 |
| 11-20 | 0.64 | 8-19 | 0.00 |
| 12-12 | 1.39 | 8-23 | 1.91 |
| 12-22 | 0.64 | 9-14 | 1.93 |
| | Sum 6.55 | 10-4 | 0.09 |
| 1960 | | | |
| 1-8 | 2.01 | 10-13 | 0.76 |
| 1-19 | 1.10 | 10-16 | 1.09 |
| 3-3 | 1.45 | 10-20 | 0.65 |
| 3-23 | 0.00 | 11-3 | 0.00 |
| 4-13 | 0.33 | 11-21 | 0.45 |
| 5-12 | 0.34 | 12-19 | 0.23 |
| | | 1960 Sum | 15.35 |

the entire root system of the treated plant. This would allow the plant to, in effect, dilute the dosage of herbicide since a certain percentage of its roots were not in the chemically treated soil. Why this should affect monuron and 2,3,6-TBA so much more than fenuron is not known.

The plots were all seeded with Lehman's lovegrass on August 19, 1960. However, the amount and distribution of rainfall was apparently unfavorable for the establishment of the grass as the seeding was a complete failure in treated and check plots alike.

Along with the last evaluation a check sheet was kept on the presence or absence of native grasses in the treated plots. In all cases there were grasses, mostly gramma (Bouteloua sp.) grasses or curly mesquite (Hilaria belangeri), present on the plots. This again was in contrast to the effect observed on larger plots.

Experiment Number 8

Title - Comparison of soil applied treatments of granular fenac with pelleted fenuron for control of turbinella oak.

Background - Various soil applied granular and pelleted herbicidal applications have shown promise for the control of turbinella oak. The sample of fenac arrived too late to be included in the larger experiments.

Reports indicated that fenac was active and persistent in the soil. Since fenuron is one of the most promising of the soil applied herbicides it was selected as a standard against which to test fenac.

Objectives -

1. To test fenac for activity on turbinella oak.
2. To compare fenuron with fenac.
3. To determine the affect of both herbicides on a well established stand of Lehman's lovegrass.

Materials and Methods - The treatments were four, eight, and sixteen pounds per acre of fenuron and fenac, also a check plot with sub-plots designated as high, medium and low levels of treatment. The sub-plot size was 35 X 35 feet in three replications of split-plot experimental design. There was a fifteen foot discard strip between plots and a five foot discard strip between sub-plots.

Fenuron was in a 25 percent pelleted form and the fenac used in this test was formulated as 10 percent granules. The applications were hand broadcast on burn sprouts of turbinella oak on July 16, 1959.

The area had been burned and seeded to Lehman's lovegrass in June of 1958. An excellent stand of grass covered the area uniformly at the time of treatment.

Results and Discussion - Fenuron was much more effective than fenac for the control of turbinella oak at this stage in these experiments. The data (Tables 17 and 18) indicates that fenuron is three to five times as effective on oak and from two to four times as effective on the grass. The amount of grass killed may be seen by comparison of the treated with check plots in Figure 7.

At the time of the last evaluation an appreciable amount of grass had reseeded itself in the fenuron treated plots and had not been killed at that time. It may be that the fenuron had leached out of the surface layer of soil and the grass roots had not yet reached the depth zone occupied by the herbicide.

The analysis of variance (Appendix Table 7) indicated that 16 lbs/acre of herbicide was better than eight pounds which was better than four pounds for the control of both grass and oak.

Experiment Number 9

Title - Effect of retreatment timing on control of turbinella oak with 2,4,5-T and silvex.

Background - Turbinella oak sprouts profusely from the crown area of the plant after top killing by fire, mechanical, or chemical methods. It has become increasingly doubtful

Table 17. Percent apparent kill of burn sprouts of turbinella oak on two evaluation dates after treatment in July of 1959 with four, eight, or sixteen pounds of fenuron or fenac.

| Treatment | Rate, lb/A | Percent Apparent Kill | | | |
|---|---|---|---|---|---|
| | | Evaluated 7-28-60 | Treatment Mean | Evaluated 10-5-60 | Treatment Mean |
| Fenuron | 4 | 20 | | 27 | |
| | 8 | 57 | | 58 | |
| | 16 | 88 | 55 | 91 | 59 |
| Fenac | 4 | 7 | | 4 | |
| | 8 | 10 | | 12 | |
| | 16 | 40 | 19 | 15 | 10 |
| Check | 0 | 2 | | 2 | |
| | 0 | 1 | | 3 | |
| | 0 | 3 | 2 | 2 | 2 |

Table 18. Percent kill of Lehman's lovegrass on two evaluation dates after treatment in July of 1959 with four, eight, or sixteen pounds per acre of fenuron or fenac.

| Treatment | Rate, lb/A | Percent Kill | | | |
|---|---|---|---|---|---|
| | | Evaluated 7-28-60 | Treatment Mean | Evaluated 10-5-60 | Treatment Mean |
| Fenuron | 4 | 37 | | 27 | |
| | 8 | 83 | | 63 | |
| | 16 | 100 | 73 | 92 | 61 |
| Fenac | 4 | 3 | | 10 | |
| | 8 | 8 | | 28 | |
| | 16 | 37 | 16 | 53 | 30 |
| Check | 0 | 2 | | 2 | |
| | 0 | 2 | | 1 | |
| | 0 | 1 | 2 | 1 | 1 |

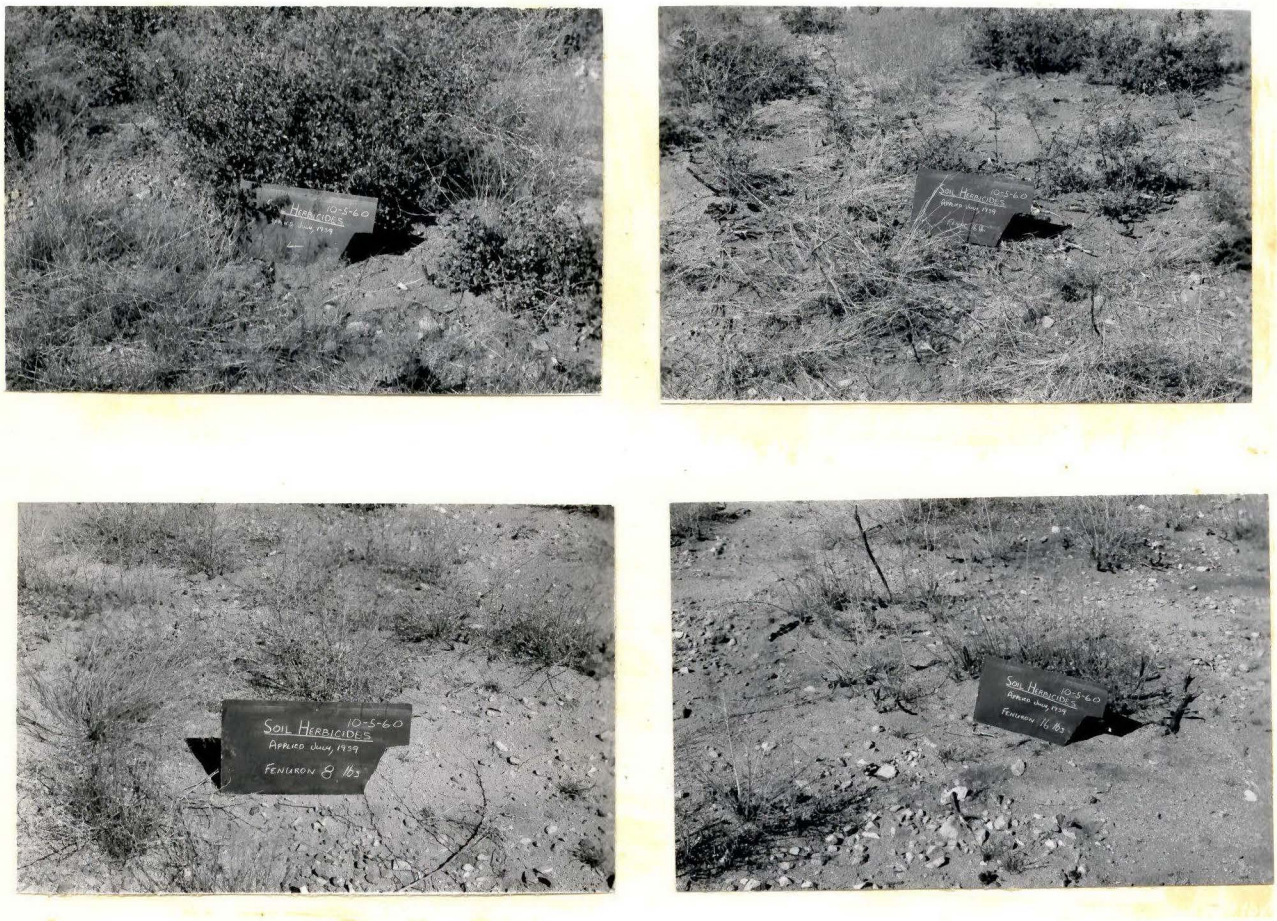


Figure 7. Pictures taken in October of 1960 of plots treated as labelled in July of 1959.

that a single foliage spray application of any of the herbicides now at hand will kill even a small percentage of the treated bushes.

Other tests have shown that a high percentage of leaf kill and some stem kill may be expected within three months after treatment with 2,4,5-T or silvex. Retreatment will be necessary to effect adequate control, but little is known about the optimum timing or frequency of these retreatments.

Objectives - The objectives of this study are to provide preliminary information on the control of turbinella oak that may be expected from retreatment of oak with phenoxy herbicides. This study was designed to provide information regarding:

1. Effect of retreatment as compared with a single treatment.
2. Timing of retreatment.
3. Minimum effective application rate.
4. Comparison of 2,4,5-T and silvex under above conditions.
5. Possible interactions of above factors.

Materials and Methods - The test consisted of 2,4,5-T and silvex applied at zero, one, two and four pounds per acre. These treatments were applied in the spring (total of one treatment), in the spring and fall (total of two treatments), in the

spring and spring (total of two), and in the spring, fall, and spring (total of three).

The herbicidal applications were made in a 1:7 diesel oil in water emulsion at 20 gpa to 25 X 60 foot plots arranged into three replications of a randomized block experimental design. Applications were made on the following dates under the indicated conditions:

1. Application date - May 5, 1959
   a. clear and sunny - temperature 75-80° F.
   b. wind up to approximately 10 mph.
2. Application date - September 29, 1959
   a. clear and sunny - temperature 65-70° F.
   b. wind approximately 10-12 mph.
3. Application date - May 18, 1960.
   a. clear and sunny - temperature approximately 70° F.
   b. wind - slight breeze.

Results and Discussion - The May 17, 1960, evaluations (Table 19) were made immediately prior to the last spring treatment. Therefore, instead of treatments applied spring, spring-fall, spring-spring, and spring-fall-spring the result at that time was two spring treatments and two spring-fall treatments. The means of these treatments were very similar, and the plots receiving two treatments resulted in a two-fold increase in

Table 19. Percent apparent kill of turbinella oak on two evaluation dates after treatment on 5-5-59, 9-29-59, and 5-18-60 with three rates of 2,4,5-T or Silvex.

| Herbicide | Rate, lb/A | Season of Treatment | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | S | S-F | S-S | S-F-S | S | S-F | S-S | S-F-S |
| | | Evaluated 5-17-60 | | | | Evaluated 10-25-60 | | | |
| | | Percent Apparent Kill | | | | | | | |
| 2,4,5-T | 0 | 2 | 1 | 4 | 3 | 6 | 7 | 10 | 7 |
| | 1 | 20 | 55 | 7 | 72 | 15 | 25 | 15 | 35 |
| | 2 | 27 | 75 | 53 | 86 | 15 | 28 | 45 | 67 |
| | 4 | 45 | 83 | 40 | 95 | 17 | 53 | 77 | 90 |
| Silvex | 0 | 3 | 6 | 3 | 5 | 4 | 6 | 7 | 7 |
| | 1 | 28 | 73 | 13 | 77 | 18 | 30 | 58 | 75 |
| | 2 | 38 | 86 | 23 | 70 | 38 | 48 | 77 | 72 |
| | 4 | 32 | 93 | 63 | 95 | 15 | 70 | 82 | 82 |
| | Mean | 24 | 59 | 26 | 63 | 16 | 33 | 46 | 54 |

in apparent kill as compared to those plots recieveing one treatment. There were no significant differences between one and two pounds or two and four pounds per acre of herbicide (Appendix Table 8).

When the October of 1960 evaluations were made all scheduled treatments had been applied. At that time those treatments that had received two or more re-applications were significantly higher in apparent kill than the treatment that received only the single spring treatment. There were no significant differences among the spring-fall, spring-spring, or spring-fall-spring treatments. Although the difference between the spring-fall applications and the spring-spring application was not significant, the percent apparent kill on the spring-spring was 16 percent higher than the spring-fall treatments. Even if this difference were significant, would the difference be due to the different season of treatment, or merely to the fact that 13 months had passed since the last application to the spring-fall treatment, while only five months had passed since the last spring-spring treatment? Comparison of the spring-spring figure of 46 (10-25 evaluation) five months after last treatment with the spring-fall figure of 59 (5-17 evaluation) seven months after last treatment would possibly be the better comparison. However, these

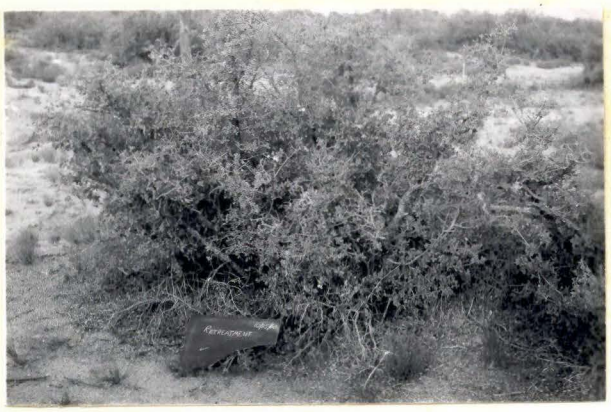

Figure 8. Pictures taken in October of 1960 of plots treated as labelled with 2,4,5-T in the spring of 1959, fall of 1959, and/or the spring of 1960.

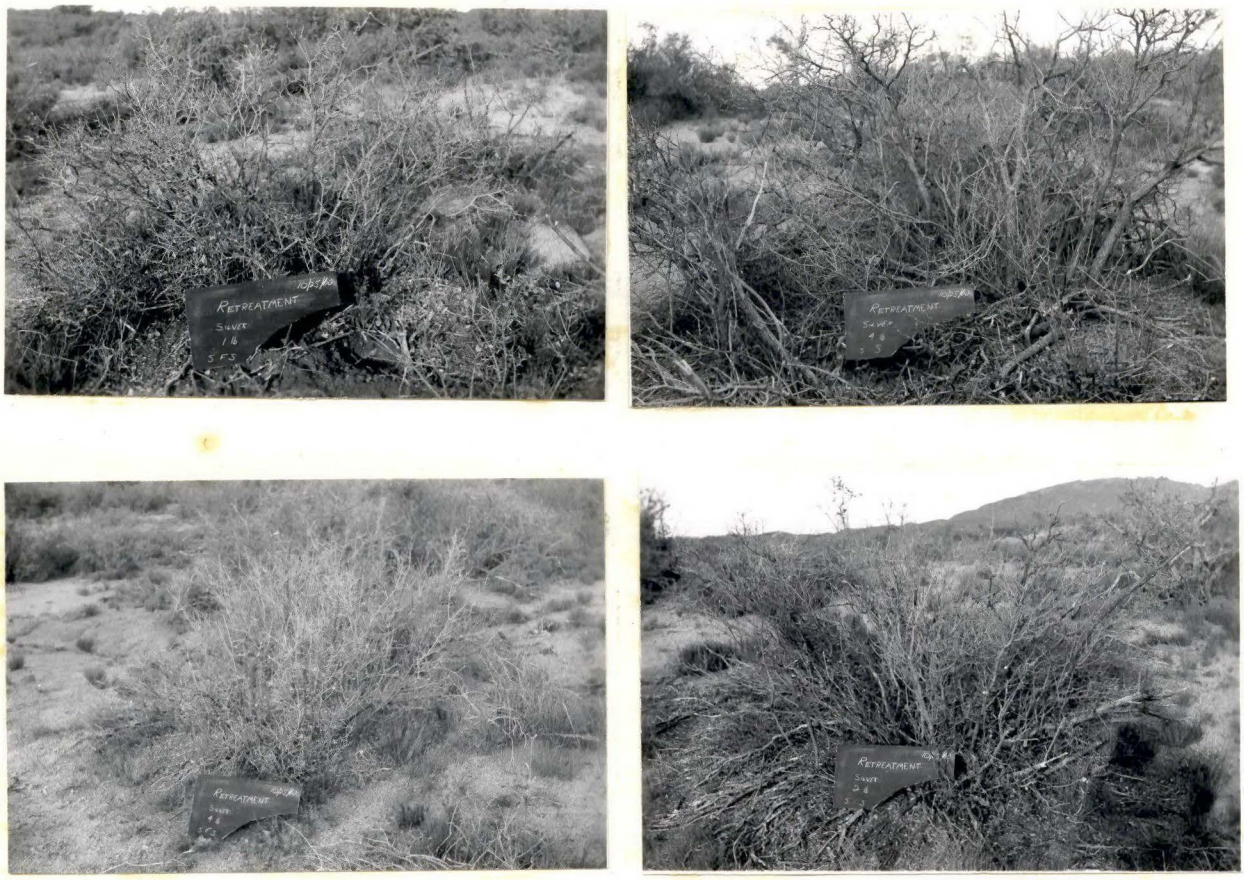


Figure 9. Pictures taken in October of 1960 of plots treated as labelled with silvex in the spring of 1959, fall of 1959, and/or the spring of 1960.

evaluations were made at different times and one interval after treatment included a growing season while the other interval after treatment did not.

This experiment serves to illustrate the problems encountered in evaluating differences in degree of injury to turbinella oak which result from treatments applied in different seasons of the year. The solution to the problem probably is that any differences which cannot be detected are not of sufficient magnitude to be of any practical importance.

At the time of the last evaluation the difference in apparent control in favor of silvex, as compared with 2,4,5-T, was highly significant.

Experiment Number 10

Title - Experiment use of ammonium thiocyanate and Hexachloroacetone for the control of turbinella oak.

Background - Turbinella oak has not responded well to foliar applications of those herbicides which are generally accepted as active on brush species. This experiment is one of a series of exploratory tests evaluating various herbicides and/or combinations of herbicides for their activity on turbinella oak.

Objective - To evaluate ammonium thiocyanate and HCA for their activity on turbinella oak.

Materials and Methods - The study was composed of single-bush plots treated with a 6 foot boom attatched to a $CO_2$ pressured back-pack sprayer. The ammonium thiocyanate was applied in aqueous solution (20 gpa) at 0, 6, 12, and 24 pounds per acre. The HCA was applied in diesel oil (20 gpa) at rates of 0, 2160, 4320, and 8640 milliliters of 75 percent concentrate per acre. The single-bush plots were assigned to five replications of a randomized block experimental design.

The initial treatments were made on August 23, 1960 and retreatment is scheduled for May of 1961.

Results and Discussion - The observations (Table 20) indicate that single applications of these herbicides did not damage the oak to an appreciable extent. However, these are only preliminary observations and the plots are scheduled for retreatment in the spring of 1961.

Experiment Number 11

Title - Sprout growth of turbinella oak as influenced by seasonal burning treatments with and without follow-up herbicidal applications.

Technical Personnel - D. T. Lillie, ARS, G. E. Glendening, USFS, and C. P. Pase, USFS.

Background - Burning of chaparral followed by seeding to perennial grass sometimes results in temporary improvement

Table 20. Percent apparent kill of turbinella oak on November 11, 1960 after treatment on August 23, 1960 with three rates of HCA and ammonium thiocyanate.

| Herbicide | Rate, lb/Acre | Percent Apparent Kill |
|---|---|---|
| HCA | 0 | 2 |
| | 5.5 | 33 |
| | 11.0 | 30 |
| | 22.0 | 29 |
| Ammonium thiocyanate | 0 | 3 |
| | 6 | 5 |
| | 12 | 8 |
| | 24 | 19 |

of chaparral rangeland. The general practice has been to burn in June (the period of greatest fire hazard) and seed immediately to perennial grass.

While this practice has enjoyed a measure of succes for the establishment of grass, the recovery of the brush species has also been rapid. It is only a matter of time (estimated at 5-7 years) until the chaparral species will re-occupy the site to the virtual exclusion of the grass. Follow-up treatment by fire, chemicals or other means will be necessary to achieve more effective conversion from chaparral to grass.

Studies in California chaparral have shown that the season of burning affects the results of follow-up chemical treatments. The species in Arizona chaparral differ from those in California, but the possibility exists that burning in seasons other than early summer may be more effective.

Objectives -

1. To determine if the amount of sprouting following burning differs from that following removal of top growth by clipping.
2. To evaluate the effects of burning and top-removal at various seasons of the year.
3. To compare silvex and 2,3,6-TBA on sprouts resulting from burning and top removal.

4 To evaluate the effect of burning plus chemical follow-up on sprout suppression.

Materials and Methods - Broadcast burning in Arizona chaparral carries with it the hazard of wildfire. To minimize this danger all treatments in this test were applied to single bush plots. To further decrease the danger in burning, all top growth was removed by clipping and the burn treatment applied to the stumps and litter with a hand torch (Figure 10).

Top removal was done at four seasons of the year and chemical follow-up was applied when the five tallest sprouts in each plot averaged about 12 inches in height.

Following is a list of the treatments which are scheduled at each season of top removal.

1. Clipped only.
2. Clipped, followed by burning.
3. Clipped, followed by silvex @ 4lb/acre.
4. Clipped, followed by 2,3,6-TBA @ 8lb/acre.
5. Clipped, burned, silvex.
6. Clipped, burned, 2,3,6-TBA.

The four seasonal top-removal treatment have been applied. Top-removal was accomplished on May 6, 1960, June 30, 1960, September 7, 1960, and October 31, 1960.

The top-removal treatments were applied to 10 replications

Figure 10. Photo taken on May 6, 1960 of burning treatment applied to previously clipped single-bush plot.

of single bush plots. The herbicidal applications were made in aqueous solutinn or emulsion at 20 gpa from a six foot boom attatched to a $CO_2$ pressured back-pack sprayer. Spray treatments have been applied only to the first two seasons of top-removal. The May 6, 1960 top-removal treatment was sprayed on September 9, 1960 and the June 30, 1960 top-removal treatment was sprayed on October 31, 1960.

Results and Discussion - No data have been taken except pre-spraying counts and measurements of sprouts.

Experiment Number 12

Title - Investigations of combined 2,3,6-TBA and amitrole for the control of turbinella oak.

Background - Of the various herbicides and combinations of herbicides applied for the control of turbinella oak one of the more effective is a combination of 2,3,6-TBA and amitrole. There are not enough plots in the field of this combination to determine if the combination is more effective than 2,3,6-TBA alone.

Objectives - The objective of this study is to determine if a combination of 2,3,6-TBA with amitrole is more effective for the control of turbinella oak than 2,3,6-TBA alone. If any synergistic affect is present a further objective is to determine the most effective proportion of 2,3,6-TBA with amitrole.

Materials and Methods - The experiment contained two herbicides, 2,3,6-TBA and amitrole. These herbicides were applied one at a time and each was applied in aqueous solution at 20 gpa. The 2,3,6-TBA was applied at 0, 4, 8, and 12 pounds per acre and the amitrole was applied at 0, 1, 2, and 4 pounds per acre. The herbicides were applied in all possible combinations resulting in a factorial experiment applied to four replications of a randomized block. The plot size was 25 X 50 feet with a 10 foot discard strip between plots.

The experiment was applied on May 12, 1960. The weather was clear and sunny with the temperature in the seventies. A wind was blowing with gusts up to 12-16 mph. The plots are scheduled for retreatment in May of 1961.

Results and Discussion - The results (Table 2/) of this experiment are preliminary. However, at this time there seems to be no advantage in combining amitrole with 2,3,6-TBA.

When the treatment sum of squares was portioned into the 2,3,6-TBA, amitrole, and amitrole X 2,3,6-TBA variance (Appendix Table 9), the variance due to rates of 2,3,6-TBA was found to be contributing 94 percent of the treatment sum of squares. The variables due to amitrole and to the interaction of 2,3,6-TBA with amitrole were not significant.

Table 21. Percent apparent kill of turbinella oak on November 11, 1960 after treatment with all possible combinations of four rates of 2,3,6-TBA and amitrole on May 12, 1960.

| | | Percent Apparent Kill | | | | |
|---|---|---|---|---|---|---|
| | | Amitrole, Pounds per Acre | | | | |
| Herbicide | Rate, lb/A | 0 | 1 | 2 | 4 | Mean |
| 2,3,6-TBA | 0 | 2 | 2 | 4 | 2 | 2 |
| | 4 | 10 | 19 | 8 | 9 | 11 |
| | 8 | 42 | 34 | 24 | 45 | 36 |
| | 12 | 47 | 45 | 46 | 61 | 50 |
| | Mean | 25 | 25 | 21 | 29 | |

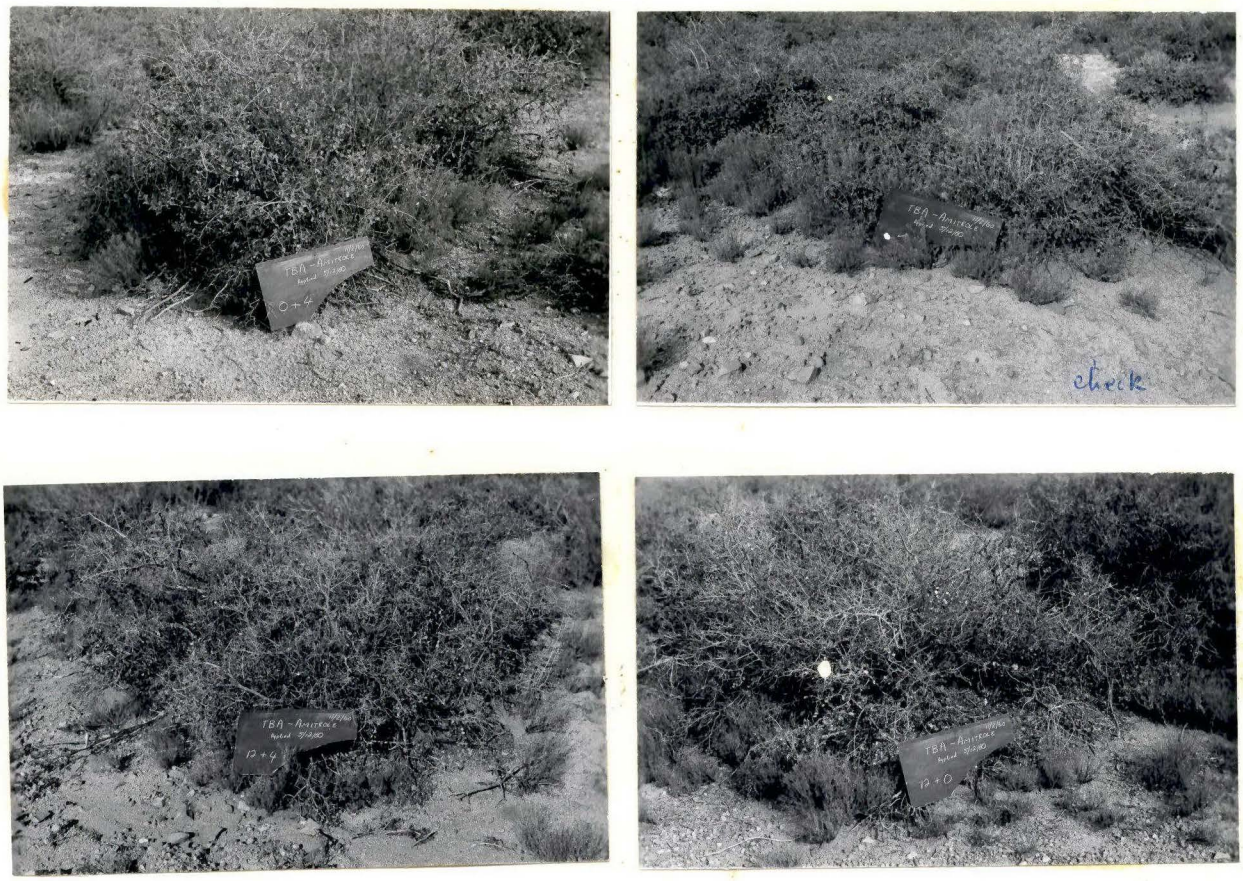


Figure 11. Pictures taken on November 2, 1960 of plots treated with combinations of 2,3,6-TBA and amitrole. Treatments as labelled in photos with rate/acre of 2,3,6-TBA given first.

Experiment Number 13

Title - Comparison of various combinations of herbicides for the control of turbinella oak.

Background - Foliar spray applications for the control of turbinella oak have been generally unrewarding. Varying amounts of top kill and/or suppression of growth have been obtained, but sprouting always occurs from the unkilled portions of the plant. It was proposed to test various herbicides singly and in combination to determine if any of the combinations are more effective than single applications.

Objectives - To test combinations of herbicides for activity on turbinella oak.

Materials and Methods - The following chemical treatments were applied on June 1, 1960 to 5 replications of single-bush plots in a randomized block field design.

| Herbicide | Rate, lb/acre |
|---|---|
| 2,3,6-TBA | 6 |
| 2,4,5-T | 2 |
| amitrole | 6 |
| CC-32292 | 8 |
| Propazine M | 8 |
| Dalapon | 10 |
| 2,3,6-TBA + Amitrole | 6 + 6 |
| 2,3,6-TBA + Propazine M | 6 + 8 |

| Herbicide | Rate, lb/acre |
|---|---|
| 2,3,6-TBA + GC 32292 | 6 + 8 |
| 2,3,6-TBA + Dalapon | 6 + 10 |
| 2,4,5-T + amitrole | 2 + 6 |
| 2,4,5-T + Propazine M | 2 + 8 |
| 2,4,5-T + GC 32292 | 2 + 8 |
| 2,4,5-T + Dalapon | 2 + 10 |
| Amitrole + Propazine M | 6 + 8 |
| Amitrole + GC 32292 | 6 + 8 |
| Amitrole + Dalapon | 6 + 10 |
| Dalapon + Propazine M | 10 + 8 |
| Dalapon + GC 32292 | 10 + 8 |
| Check | 0 |

The plot area had been burned over by a wildfire in June of 1959. The applications were made to burn sprouts.

Each herbicide was applied to each plot scheduled to receive that herbicide from a six foot boom attatched to a $CO_2$ pressured back-pack sprayer. The applications were made in 20 gpa of an aqueous solutions, emulsion, or slurry. Retreatment is scheduled for the spring of 1961.

Results and Discussion - The results of this experiment (Table 22) are preliminary at this time.

Table 22. Percent apparent kill of turbinella oak on two date of evaluation after treatment on June 1, 1960 with various herbicides both singly and in combination.

| Date of Evaluation | | | | | |
|---|---|---|---|---|---|
| 6-28-60 | | | 11-29-60 | | |
| Herbicide | Rate, lb/A | *Percent Apparent Kill | Herbicide | Rate, lb/A | *Percent Apparent Kill |
| Check | 0 | 8 a | Check | 0 | 1 e |
| Dalapon+Propazine-M | 10+8 | 9 a | Dalapon+Propazine-M | 10+8 | 3 e |
| Propazine-M | 8 | 10 a | Propazine-M | 8 | 5 e |
| GC 32292 | 8 | 12 a | Dalapon | 10 | 5 e |
| Dalapon | 10 | 12 a | Amitrole+Dalapon | 6+10 | 5 e |
| Amitrole | 6 | 16 a | GC 32292 | 8 | 5 e |
| Dalapon+GC 32292 | 10+8 | 18 a | Dalapon+GC 32292 | 10+8 | 8 e d |
| Amitrole+Propazine-M | 6+8 | 18 a | Amitrole+Propazine-M | 6+8 | 8 e d |
| Amitrole+ GC 32292 | 6+8 | 20 a | Amitrole | 6 | 8 e d |
| Amitrole+Dalapon | 6+10 | 20 a | Amitrole+GC 32292 | 6+8 | 11 e d |
| 2,4,5-T+Amitrole | 2+6 | 38 b | 2,4,5-T+GC 32292 | 2+8 | 12 e d |
| 2,4,5-T+Dalapon | 2+10 | 40 b | 2,4,5-T+Dalapon | 2+10 | 16 d |
| 2,4,5-T+GC 32292 | 2+8 | 42 b | 2,4,5-T+Amitrole | 2+6 | 17 d |
| 2,4,5-T | 2 | 42 b | 2,4,5-T+Propazine-M | 2+8 | 20 d |
| 2,4,5-T+Propazine | 2+8 | 54b | 2,4,5-T | 2 | 29 a d |
| 2,3,6-TBA | 6 | 78 c | 2,3,6-TBA | 6 | 43 a c |
| 2,3,6-TBA+Propazine-M | 6+8 | 82 c | 2,3,6-TBA+GC 32292 | 6+8 | 52 c |
| 2,3,6-TBA+GC 32292 | 6+8 | 88 c | 2,3,6-TBA+Propazine-M | 6+8 | 52 c |
| 2,3,6-TBA+Amitrole | 6+6 | 89 d | 2,3,6-TBA+Dalapon | 6+10 | 79 b |
| 2,3,6-TBA+Dalapon | 6+10 | 98 d | 2,3,6-TBA+Amitrole | 6+6 | 83 b |

* All means not followed by the same letter differ at the 5 percent probability level.

The percent apparent kill on those plots receiving 2,3,6-TBA was significantly higher (Table 2, Appendix 12) than on plots not receiving this herbicide. The plots receiving herbicidal applications in combination with 2,3,6-TBA were, in all cases, equal to or better than 2,3,6-TBA alone. At the time of the November 29, 1960 evaluation all apparent kill figures for 2,3,6-TBA combinations were more than additive with the herbicides in question applied singly. This is in contrast to the combinations with 2,4,5-T where the effect of the combinations was antagonistic.

2,3,6-TBA and 2,4,5-T were the most effective herbicides in the experiment whether applied singly or in combination.

Figure 12 shows photos of some of the better treatments and serves to illustrate the size of bushes treated as well as their rapidity of recovery following the June of 1959 wildfire.

Experiment Number 14

Title - Seasonal applications of 2,3,6-TBA and 2,4,5-T for the control of turbinella oak.

Background - The test originally initiated to test the effect of seasonal applications of herbicides was partially destroyed by fire. That original test was somewhat too ambitious to be applied easily and it contained several treatments which have since been shown to be ineffective.

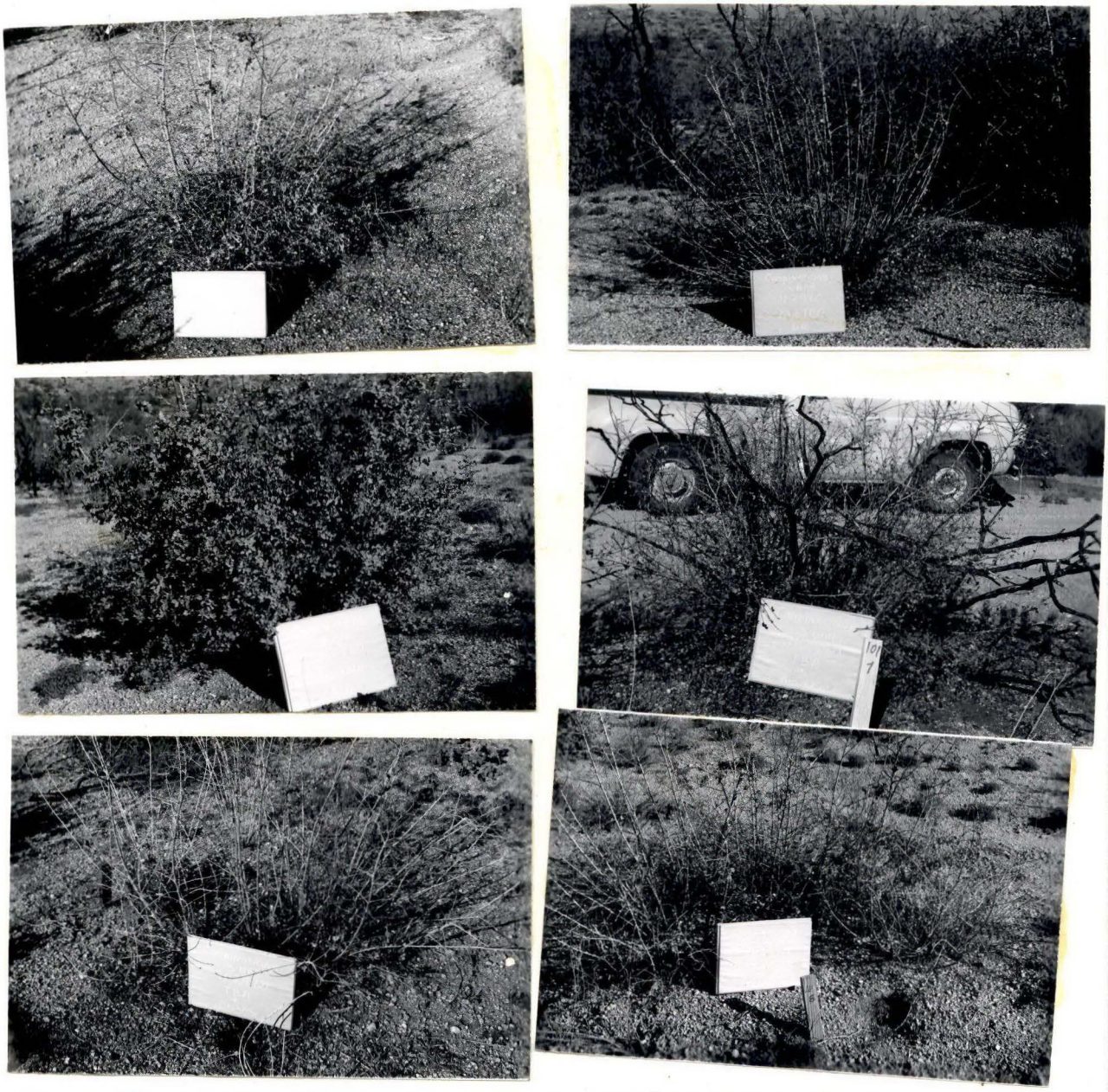

Figure 12. Pictures taken on November 29, 1960 of single-bush plots treated with various combinations of herbicides. Left to right: upper, 2,4,5-T - 2,3,6-TBA; middle, amitrole - 2,3,6-TBA plus amitrole; lower, 2,3,6-TBA plus dalapon - 2,3,6-TBA plus propazine.

A new and simpler test was initiated to evaluate any seasonal effect of sufficient magnitude to be detected. This test contained only one rate of two of the more active (on turbinella oak) herbicides and was applied with a back-pack sprayer to single bush plots. This simplified test could be applied much more easily, and therefore oftener, than could the original season test.

Materials and Methods - The treatments in this test consisted of a check, four pounds per acre of 2,4,5-T, and six pounds per acre of 2,3,6-TBA applied on the following dates:

1. 4-15-60
2. 4-20-60
3. 4-26-60
4. 5-3-60
5. 5-9-60
6. 5-19-60
7. 5-31-60
8. 6-16-60
9. 6-29-60
10. 7-9-60
11. 8-10-60
12. 9-13-60
13. 11-18-60

The treatments were made in aqueous solution or emulsion at 20 gpa from a six foot boom attatched to a $CO_2$ pressured back-pack sprayer. The plots consisted of a single bush or clump of burn sprouts resulting from a June 1959 wildfire. There were eight replications.

Results and Discussion - No data have been taken yet.

Experiment Number 15

Title - Comparison of various benzoic acid derivatives for the control of turbinella oak.

Background - Previous experiments have shown that the benzoic acid derivatives are among the more effective classes of compounds applied for the control of turbinella oak. An evaluation of all readily available benzoic acid derivatives was conducted in the laboratory by Dr. E. A. Davis. The most active compounds in this series were selected to be field tested in this experiment.

Materials and Methods - Four and eight pounds per acre of dimethylamine-2,3,6-trichlorobenzoate, dimethylamine-polychlorobenzoate, dimethylamine-2-methoxy-3, 6-dichlorobenzoate, sodium-2-methoxy-3, 6-dichlorobenzoate, and triethanolamine-2, 3,5,6-tetrachlorobenzoate were applied in 20 gpa of aqueous solution to five replications of single bush plots on June 22, 1960. The applications were made from a six foot boom attatched to a $CO_2$ pressured back-pack sprayer. The temperature was 75-80° F. and the sky was overcast without appreciable wind. Colloidal X-77 wetting agent was added at a ratio of 10 ml wetting agent/1 gallon of spray mixture.

All dead wood was clipped out of the treated bushes and masking tape was placed around three stems on each bush at one inch behind the terminal bud.

The plots are scheduled for retreatment in the spring of 1961.

Results and Discussion - The preliminary results (Table 23 and Figure 13) indicate there were no significant differences among treatments (Appendix Table 11).

Results in the spring of 1961 prior to retreatment will be more meaningful. Measurements of growth will be made at that time.

Experiment Number 16

Title - Effect on Quercus turbinella of various herbicides applied to the soil in granular or pelleted form (ammendment to experiment number 3).

Objectives - Preliminary observations of the original study indicated that fenuron and 2,3,6-TBA were among the most active of soil-applied herbicides for the control of turbinella oak. The objectives of this study were to compare two subsitututed urea compounds with each other and with several formulations of benzoic acid derivatives. Ammonium thiocyante was included because it has not been tested as a soil applied herbicide on turbinella oak.

Materials and Methods - Granular formulations of PBA acid, 2,3,6-TBA acid, and the sodium salt of 2,3,5-TBA were obtained from commercial sources. The amine salt of 2,3,6-TBA was impregnated on attclay in the manner reported in experiment number 3. Fenuron and Fenuron-TCA pellets were obtained from commercial sources. Technical Ammonium thiocyanate was mixed with attaclay for application.

Table 23. Percent apparent kill of turbinella oak on November 11, 1960 after treatment with four and eight pounds per acre of various benzoic acid derivatives on June 22, 1960.

| Herbicide | Rate, lb/Acre | Percent Apparent Kill | Treatment Mean* |
|---|---|---|---|
| Check | 0 | 3.0 | |
| | 0 | 2.0 | 2.5 b |
| 2,3,5,6 Tetra-BA | 4 | 29.0 | |
| | 8 | 14.0 | 21.5 a b |
| 2,3,6-TBA | 4 | 17.4 | |
| | 8 | 33.0 | 25.0 a b |
| 2-methoxy-3,6-DBA (sodium salt) | 4 | 30.0 | |
| | 8 | 42.0 | 36.0 a |
| PBA | 4 | 31.0 | |
| | 8 | 43.0 | 37.0 a |
| 2-methoxy-3,6-DBA (amine salt) | 4 | 48.0 | |
| | 8 | 51.0 | 49.5 a |

* All means not followed by the same letter differ at the 5 percent probability level.

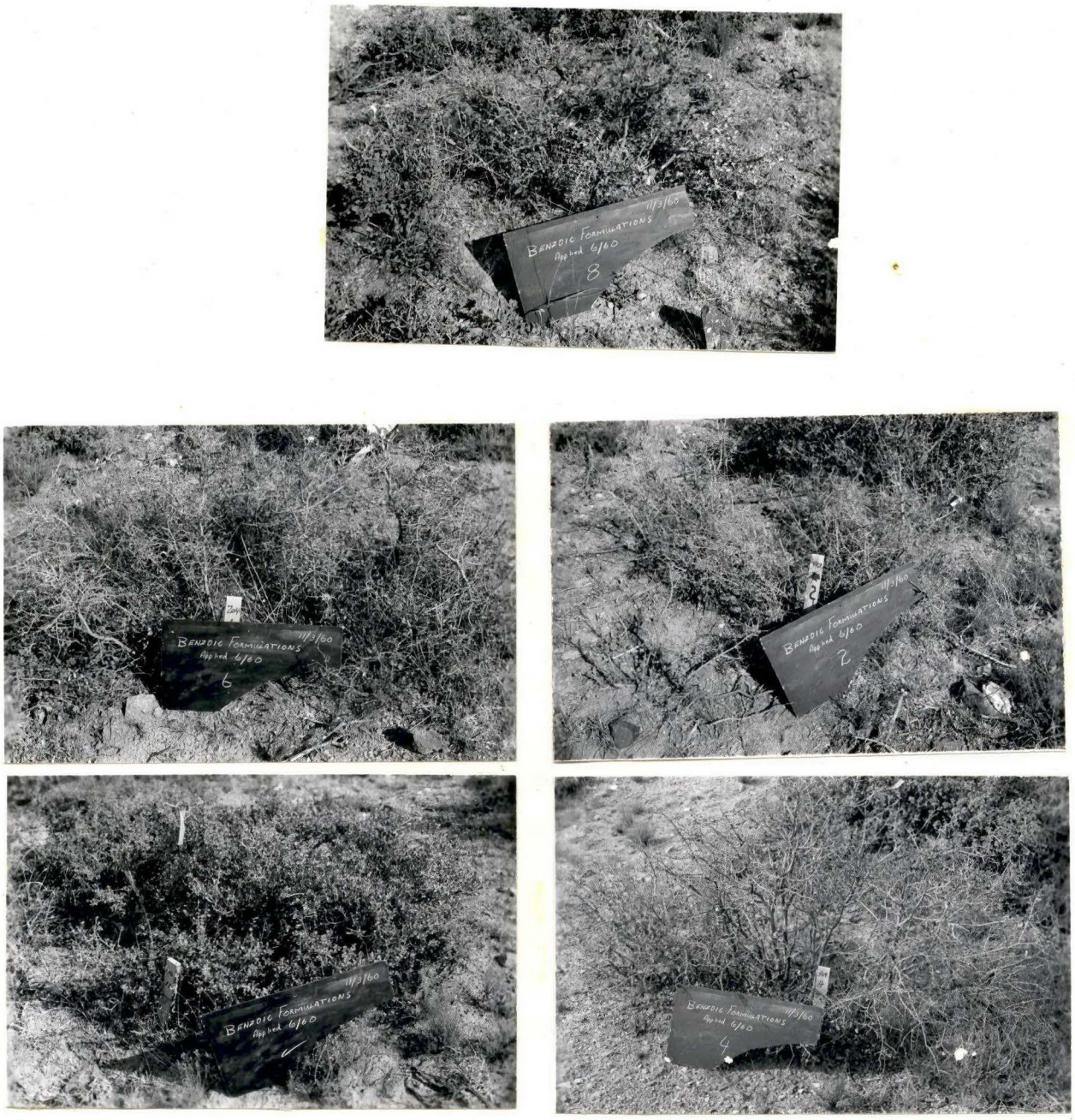


Figure 13. Pictures taken on November 3, 1960 of single-bush plots treated in June of 1960 with various benzoic acid derivatives. Upper, check; middle, left - 2,3,6-TBA, right PBA; lower, left - 2-methoxy 3,6-DBA (amine), right - 2-methoxy-3,6-DBA (sodium).

Following is a schedule of treatments:

| Herbicide | Form | Concentration | Rate, lbs/acre |
|---|---|---|---|
| Ammonium thiocyanate | Mixed with Attaclay | 100% | 100 and 200 |
| Fenuron | pelleted | 25% | 10 and 20 |
| Fenuron-TCA | pelleted | 22% | 10 and 20 |
| 2,3,6-TBA (acid) | granular | 25% | 10 and 20 |
| 2,3,6-TBA (amine) | granular | 6.75% | 10 and 20 |
| 2,3,6-TBA (sodium) | granular | 5.5% | 10 |
| PBA | granular | 25% | 10 and 20 |
| Check | - | - | 0 |

The treatments were hand-broadcasted on July 29, 1960, over 30 X 30 foot plots in four replications of a randomized block experimental field design. The herbicide for each plot was weighed into two equal aliquots and each half of the plot treated separately. There were five foot isolation strips between plots.

Results and Discussion - The results of this experiment (Table 24, Figure 14) are much to preliminary for any but the most general comments.

It is apparent that fenuron was effective and rapid in action. Ammonium thiocynate was relatively ineffective or much slower to act than the other herbicides.

Results taken in about two years will be more meaningful, at the present time there is little room for comment.

Table 24. Percent apparent kill of turbinella oak on October 13, 1960 after treatment on July 20, 1960 with various granular or pelleted formulations of herbicides.

| Herbicide | Rate, lbs/Acre | Percent Apparent Kill |
|---|---|---|
| Check | 0 | 4 a |
| Ammonium thiocyanate | 100 | 14 a b |
| | 200 | 16 a b |
| 2,3,6-TBA (amine) | 10 | 16 a b |
| Fenuron-TCA | 10 | 31 c b |
| 2,3,6-TBA (Sodium) | 10 | 44 c e |
| PBA | 20 | 46 c d e |
| 2,3,6-TBA (acid) | 10 | 47 c d e |
| 2,3,6-TBA (acid) | 20 | 50 c d e |
| PBA | 10 | 56 c d e |
| 2,3,6-TBA (Amine) | 20 | 66 d e |
| Fenuron-TCA | 20 | 66 d e |
| Fenuron | 10 | 66 d e |
| Fenuron | 20 | 76 d |

* All means not followed by the same letter differ at the five percent level.

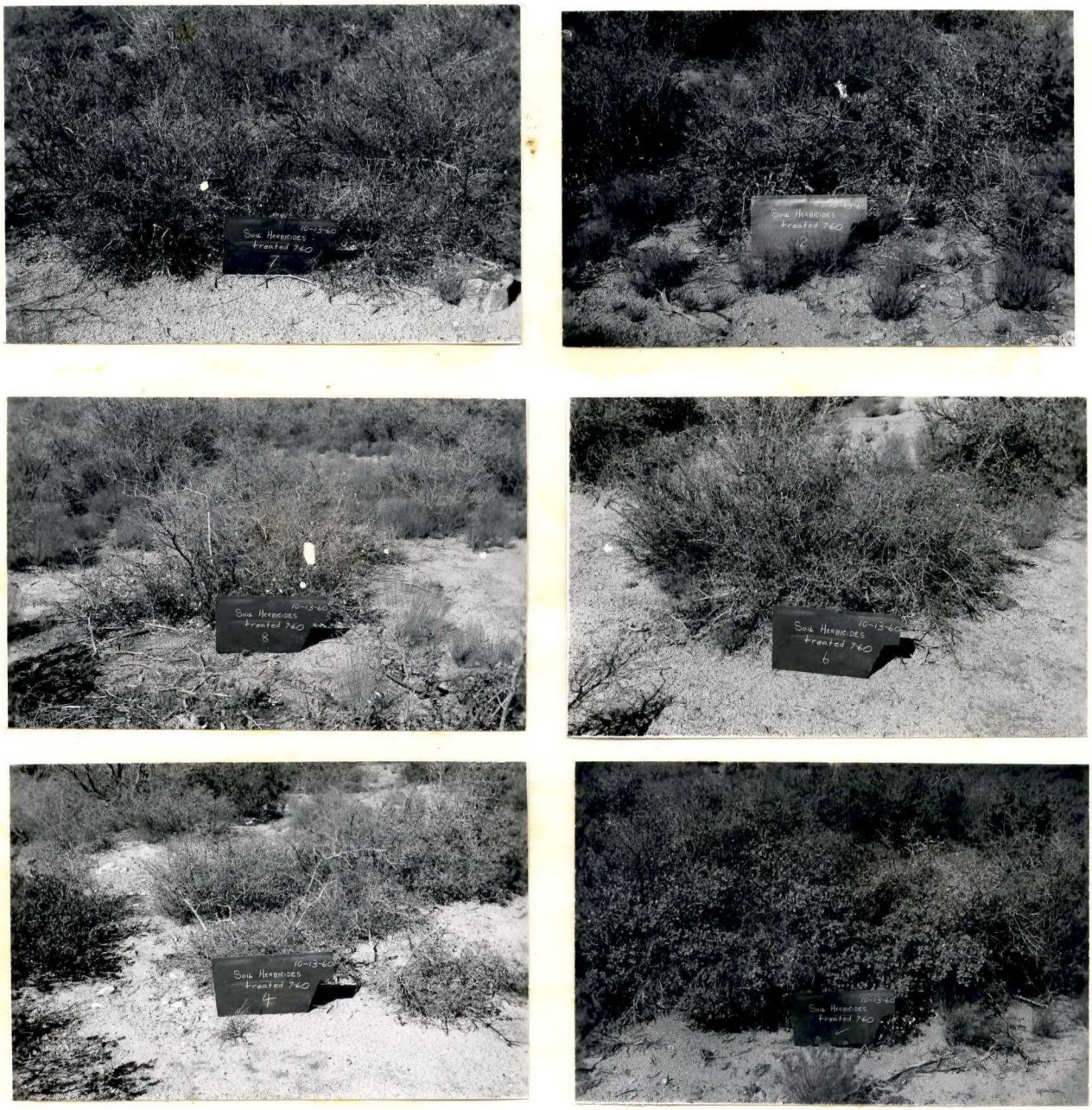


Figure 14. Pictures taken on October 13, 1960 of various granular or pelleted tests applied in July of 1960. From left to right: upper - check, Fenuron 20 lb.; middle - Fenuron-TCA 20 lb., 2,3,6-TBA 20 lb.; lower - 2,3,6-TBA acid 10 lb., PBA acid 20 lb.

## MEETINGS ATTENDED

1. National Weed Control Conference - Denver, Colorado

   5 days

2. Salt River Water Users' Association - Phoenix, Arizona

   1 day

3. Forest Supervisor's Meeting - Silver City, New Mexico

   2 days - participated

4. Extension Range Meeting - Dewey, Arizona

   1 day - participated

5. American Society of Range Management, Arizona Section -

   Prescott, Arizona

   2 days - participated

LIST OF HERBICIDES

| Chemical Name | Abbreviation | Source | Commercial Designation |
|---|---|---|---|
| 2,4,5-Trichlorophenoxy acetic acid (PGBE ester) | 2,4,5-T | Dow[1] | Esteron 245 |
| 2,4,5-Trichlorophenoxy acetic acid (Butoxyethanol ester) | 2,4,5-T | Amchem[2] | Weedone 2,4,5-T |
| 2-(2,4,5-Trichlorophenoxy) propionic acid (PGBE ester) | silvex | Dow | Silvex |
| 2,4,5-Trichlorophenoxy acetic acid (PGBE ester Forron formulation) | 2,4,5-T Forron | Dow | M-1094 |
| 2-(2,4,5-Trichlorophenoxy propionic acid (PGBE ester Forron formulation) | silvex Forron | Dow | M-1445 |
| Dimethylamine 2,3,6-Trichlorobenzoate | 2,3,6-TBA amine | Dupont[3] | Tryben 200 |
| 2,3,6-Trichlorobenzoic acid (granular) | 2,3,6-TBA | Dupont | TBA 25 |
| Polychlorobenzoic acid | PBA | Amchem | Benzac |
| 3-(p-Chlorophenyl)-1, 1-Dimethylurea (Pelleted) | Monuron | Dupont | Monuron 25% pellets |
| 3-Phenyl-1,1-Dimethylurea | Fenuron | DuPont | Karmex FP |
| 2-Chloro-4,6-bis-(ethylamino)-s-triazine (granular) | Simazine | Geigy[4] | Simazine |
| 3-(p-Chlorophenyl)-1,1-Dimethylurea·Trichloracetate | Monuron-TCA | G.C.[5] | Urox |
| 3-Phenyl-1,1-Dimethylurea· Trichloroacetate | Fenuron-TCA | G.C. | Urab |

| Chemical Name | Abbreviation | Source | Commercial Designation |
|---|---|---|---|
| 2,4-Dichlorophenoxy acetic acid (PGHE ester) | 2,4,-D | Dow | Esteron ten-ten |
| 2,3,6-Trichlorophenyl acid amide | Fenac | Amchem | ACP M-906 |
| 3-Amino-1,2,4-Triazol | Amitrole | Amchem | Weedazol |
| 3-Amino-1,2,4-Triazol-ammonium thiocyanate | Amitrole-T | Amchem | ACP M-569 |
| 4,6-Dinitro-Ortho-secondary Butylphenol | DNBP | Dow | Dow General |
| 2-Methoxy-4,6-bis-(isopropylamino) s-triazine | Propazine-M | Geigy | Propazine-M |
| 2-Methoxy-4-isopropylamino-6-methylamino-S-triazine | GC-32292 | Geigy | GC-32292 |
| Dimethylamine-2-methoxy-3, 6-dichlorobenzoate | | Velsicol 6/ | |
| Triethanolamine-2,3,5,6-tetrachlorobenzoate | | Amchem | |
| Sodium-2-methoxy-3,6-dichlorobenzoate | | Velsicol | |

1/ Dow Chemical Company, Midland, Michigan

2/ Amchem Products Incorporated, Ambler, Pennsylvania

3/ E. I. du Pont de Nemours and Company Incorporated, Wilmington, Delaware

4/ Geigy Agricultural Chemicals, Yonkers, New York

5/ General Chemicals Division, Allied Chemical and Dye Corporation Morristown, New Jersey

6/ Velsicol Chemical Corp., Chicago, Illinois

Appendix Table1. Summary of analysis of variance performed on arcsin transformed data of apparent topkill of turbinella oak on plots evaluated on two dates after treatment with various herbicides in September of 1958 and 1959.

| Source | Degree of Freedom | Mean Square Evaluated 7-60 | Mean Square Evaluated 9-60 |
|---|---|---|---|
| Total | 47 | | |
| Replications | 2 | 139.5 | 83.5 |
| Treatments | 7 | 470.8** | 640.4** |
| Rate | 1 | 1541.0** | 1599.0** |
| Treatment X Rate | 7 | 182.1 | 151.3 |
| Error | 30 | 98.7 | 118.1 |

** Significant at the one percent probability level.

Appendix Table 2. Summary of analysis of variance performed on arcsin transformed data of apparent topkill of turbinella oak on plots evaluated on two dates after treatment with various herbicides in March of 1959 and 1960.

| Source | Degree of Freedom | Mean Square Evaluated 7-14-60 | Mean Square Evaluated 10-5-60 |
|---|---|---|---|
| Total | 53 | | |
| Replications | 2 | 163.0 | 107.5 |
| Treatment | 8 | 802.2** | 531.5** |
| Rate | 1 | 357.0* | 697.0** |
| Treatment X Rate | 8 | 242.9** | 126.4 |
| Error | 34 | 75.5 | 66.8 |

* Significant at the five percent level.

** Significant at the one percent level.

Appendix Table 3. Summary of analysis of variance performed on arcsin transformed data of apparent kill of turbinella oak on plots treated with two rates of three formulations of 2,4,5-T and silvex.

| Source | Degree of Freedom | Mean Square Evaluated 5-24-60 | Mean Square Evaluated 10-25-60 |
|---|---|---|---|
| Total | 71 | | |
| Replications | 3 | 111 | 141* |
| Chemicals | 1 | 545** | 550** |
| Rates | 2 | 2046** | 12576** |
| Formulations | 2 | 55 | 1498** |
| Chem. X Rate | 2 | 380* | 117 |
| Chem. X Form. | 2 | 82 | 94 |
| Form. X Rate | 4 | 183 | 448** |
| Chem. X Form. X Rate | 4 | 163 | 643** |
| Error | 51 | 51.2 | 37.35 |

* Significant at the five percent level.

** Significant at the one percent level.

Appendix Table 4. Summary of analysis of variance performed on arcsin transformed data of apparent kill of turbinella oak on two dates after treatment in December of 1958 with various pelleted or granular herbicides.

| Source | Degree of Freedom | Mean Square Evaluated 7-14-60 | Mean Square Evaluated 10-25-60 |
|---|---|---|---|
| Total | 89 | | |
| Replications | 2 | 36.5 | 14.5 |
| Treatment | 9 | 3,473.0** | 3,749.0** |
| Error a | 18 | 32.4 | 61.9 |
| Rates | 2 | 1,101.0** | 1,058.0** |
| Treatment X Rate | 18 | 155.8** | 165.0 |
| Error b | 40 | 19.8 | 149.0 |

** Significant at the one percent level.

Appendix Table 5. Summary of analysis of variance performed on arcsin transformed data of apparent kill of turbinella oak on two dates after treatment in July of 1959 with various granular or pelleted herbicides.

| Source | Degree of Freedom | Mean Square Evaluated 7-15-60 | Mean Square Evaluated 10-25-60 |
|---|---|---|---|
| Total | 80 | | |
| Replications | 2 | 3.5 | 71.0 |
| Treatments | 8 | 1,695.0** | 2,348.6** |
| Error a | 16 | 47.8 | 101.1 |
| Rate | 2 | 1,719.0** | 2,322.5** |
| Treatment X Rate | 16 | 74.1 | 169.9** |
| Error b | 36 | 40.6 | 41.5 |

** Significant at the one percent level.

Appendix Table 6. Summary of analysis of variance performed on arcsin transformed data of apparent kill of turbinella oak on two dates after treatment in the spring, fall, and both spring and fall with two lbs/acre of 2,3,6-TBA and 2,4,5-T.

| Source | Degree of Freedom | Mean Square Evaluated 5-12-60 | Mean Square Evaluated 10-3-60 |
|---|---|---|---|
| Total | 41 | | |
| Treatments | 6 | 1392.0** | 509** |
| Replications | 5 | 109.6 | 102* |
| Error | 30 | 84.1 | 29.5 |

* Significant at the 5 percent level.

** Significant at the 1 percent level.

Appendix Table 7. Summary of analysis of variance performed on arcsin transformed data of percent apparent kill of oak and kill of grass on two evaluation dates after treatment in July of 1959 with three rates of femuron and fenac.

| Source | Degree of Freedom | Mean Square: Evaluated 10-5-60 oak | Mean Square: Evaluated 10-5-60 grass | Mean Square: Evaluated 7-28-60 oak | Mean Square: Evaluated 7-28-60 grass |
|---|---|---|---|---|---|
| Total | 26 | | | | |
| Treatment | 2 | 4635.0** | 4627.5** | 2787.0** | 8406.0** |
| Replications | 2 | 41.7 | 182.0 | 91.5 | 14.0 |
| Error a | 4 | 85.7 | 247.5 | 14.5 | 183.0 |
| Rates | 2 | 784.5** | 1237.0** | 1753.0** | 2431.0** |
| Treatment X Rate | 4 | 383.5** | 385.0** | 176.0 | 289.0 |
| Error b | 12 | 30.9 | 50.5 | 29.9 | 38.9 |

** Significant at the one percent level.

Appendix Table 8. Summary of analysis of variance performed on arcsin transformed data taken on two evaluation dates after treatment of turbinella oak on 3 dates with 3 rates of 2,4,5-T and silvex.

| Source | Degree of Freedom | Mean Square Evaluated 5-17-60 | Mean Square Evaluated 10-25-60 |
|---|---|---|---|
| Total | 95 | | |
| Replications | 2 | 25.5 | 85.5 |
| Treatments | 1 | 80.0 | 1,121.0** |
| Rate | 3 | 10,532.0** | 6,304.0** |
| Season | 3 | 4,439.0** | 2,709.0** |
| Treatment X Rate | 3 | 132.0 | 377.0 |
| Treatment X Season | 3 | 165.3 | 83.3 |
| Rate X Season | 9 | 567.0** | 405.8** |
| Error | 71 | 90.8 | 73.7 |

** Significant at the one percent level.

Appendix Table 9. Summary of analysis of variance performed on arcsin transformed percent apparent kill data taken on November 2, 1960 after treatment with combinations of 2,3,6-TBA and amitrole on May 12, 1960.

| Source | Degrees of Freedom | Sum of Squares | Mean Square |
|---|---|---|---|
| Total | 63 | 14,676 | |
| Replications | 3 | 219 | 73 |
| Treatments | 15 | 12,784 | 852** |
| 2,3,6-TBA | (3) | (12,053) | (4014)** |
| Amitrole | (9) | (86) | (29) |
| Amitrole + TBA | (9) | (645) | (72) |
| Error | 45 | 1,673 | 37 |

** Significant at the 1 percent level.

Appendix Table 10. Summary of analysis of variance performed on arcsin transformed data taken on two dates following a 6-1-60 treatment of turbinella oak with various herbicides both singly and in combination.

| Source | Degree of Freedom | Date of Evaluation 6-28-60 Mean Square | 11-29-60 Mean Square |
|---|---|---|---|
| Total | 99 | | |
| Replications | 4 | 456.0** | 513.0** |
| Treatments | 19 | 2437.0** | 1629.7** |
| Error | 76 | 90.3 | 65.3 |

** Significant at the one percent level.